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J. F. KELLY, Editor

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THE IRON AND STEEL INDUSTRY INVITED

EDITORIAL

The Engineer and His Relation to National Progress

By MARTIN J. CONWAY*

The wealth and economic progress of the United States have no parallel in history.

The richest countries of the past had probably a total wealth far below what several States of the Union can show today. The total wealth of the United States is not only stupendous in itself but it is growing at a rate which would have been considered absolutely unbelievable only a score of years ago.

In the last decade, the wealth of the United States has almost doubled and today is estimated at more than three hundred billion dollars. The national income is estimated at eighty-nine billion dollars, which is greater than the total national wealth of Great Britain. The total daily revenue of American railroads is close to twenty million dollars. The bank clearings are of the order of one billion, five hundred million dollars a day, while seven million telegraph messages and seventy-two million telephone calls are required every twenty-four hours to handle the vast business of the country.

When one tries, however, to determine the vital factors which led to this great economic development of the country, he is struck particularly by the fact that the development of the territory and industries of the United States was accomplished with an amazingly small amount of man power.

Here was a continent stretching some two thousand miles from the Canadian frontier to the Mexican border and more than three thousand miles from the Atlantic to the Pacific. It was not an easy continent to develop, intersected as it was by primeval forests, great and often unruly rivers, many mountain ranges and deserts, and to make things still more difficult, a warlike and unfriendly aboriginal population.

Under similar conditions in Australia and Canada development has been slow and is still limited to comparatively narrow belts along rivers and along the few existing railroad lines. In the United States it covers practically every foot of the territory.

It is obvious that the few white pioneers could not have carried through these great developments had they not been assisted by the flood of mechanical devices which were made available from the very beginning of American civilization by native talent.

While railroads were first built in England, the rail mileage in America, nevertheless, soon exceeded that of their native country.

Some of the recent achievements of the mechanical engineer are as follows: Single turbine generators capable of producing 208,000 kw. coal consumption of .9 lb. per kw. hour of output. Diesel engines with an output of 15,000 h.p. per unit. Boilers working at a pressure of 3200 lbs. per sq. in. Locomotives so huge that the slightest increase in any direction would prevent them from going through existing tunnels. Airplanes with a cruising radius of more than 4,500 miles.

With the advent of agriculture came various implements for digging and planting in the fertile earth of the tropical regions where the major portion of the earth's population then existed. Evidently, these implements were made from sharpened sticks and bones, and formed the first period of development. As demands for space made it necessary that some of the people reside on the uplands and in the more temperate zones, there came a second period when deeper cultivation was necessary, which resulted in the development of crude ploughs drawn by beasts of burden.

A third period followed many years later when implements of metal were introduced for tillage of lands still more difficult to cultivate profitably. We are now in the early part of a fourth period, that of machinery and power application.

One of the most important factors in this new power era of agriculture is the tractor. For instance, it is now possible for two men to harvest and thresh a field of grain with no more effort than formerly was required by three men and four horses for the cutting operations, and a large and cumbersome machine with a force of about ten men for threshing. It is not difficult to visualize the saving resulting from the elimination of the usual cutting, shocking, hauling and stacking operations, and possible spoilage accompanying periods of waiting for the community threshing outfit.

Crops are cultivated four times as rapidly as formerly and with one-third to one-quarter the manual labor. New types of tractors with frame clearance permitting straddling of waist-high rows of plants carry many of the implements formerly drawn by horses. Seeders of twice the capacity of the horse-drawn type are drawn with almost twice their speed, and nightfall finds a continuation of operations with lighting equipment.

The eternal battle against insect pests is being more successfully waged with the assistance of mechanical equipment. Dusting and spraying operations in the cotton, potato and tobacco fields are handled directly from the tractor, and even airplanes

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*Comb. Engr., Lukens Steel Company, Coatesville, Pa.

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ELECTRIC HEATING CONFERENCE

— AUSPICES —

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INTRODUCTORY REMARKS

Professor J. O. Keller: Gentlemen, the hour has arrived for the session to begin, and before I turn the meeting over to Mr. Davis I should like to say a few words about the purposes of this conference.

This is the third industrial electric heating conference promoted by the Pennsylvania State College. The first two were held at the College. At these two meetings we were able to obtain, for the most part, manufacturers of equipment and utility representatives, but we did not have as many of the users of electric power for heating as we had hoped to have. Consequently at the suggestion of a great many men in the Pittsburgh district. we decided to hold the third meeting in a large industrial district, and chose Pittsburgh on account of the interest that was shown.

Before going about this, we thought that it would be a good idea to ask the Association of Iron and Steel Electrical Engineers, to help us on this, and they were willing to do that; not only very willing to do it, but they did about the whole thing, so that we haven't had to do a great deal this time, practically, except come out here and meet with Mr. Kelly once or twice. The Association of Iron and Steel Electrical Engineers has been very kind in taking care of all publicity, and taking care of the details of the meeting, and about the only thing we have had to do was to arrange for the program, and even in that respect the A. I. & S. E. E. has been very helpful.

Of course, our interest in this project is from the educational point of view, and we felt that the people whom we really want to come here are those users of electric power who are interested in the papers, and who wish to know more about the application of electricity to their business in heating and welding. In other words, we are furthering technical education.

I shall now turn the meeting to Mr. E. Tyler Davis, Vice President of the Tyler Tube and Pipe Company, Washington, Pa.

E. Tyler Davis: In opening a session of this gathering devoted to the use of electricity in heating and welding I do not believe it amiss to comment on the keenness of the interest now being displayed by the iron and steel industry in the substitution of electricity for the older agents such as coal, gas and related fuels. In the branch of the industry which I am connected with, the making of tubular products, the application of electricity to process work is still very young and many obstacles still remain to be overcome despite some very excellent progress by a few manufacturers and an unusually ready acceptance of the products of the new methods. I am referring now to electric welding wherein the great contrast between the use of the electric method requiring only localized heating near the point to be welded is in such contrast to the older gas methods of welding wherein the entire mass of metal has to be heated up in order to accomplish the same purpose. The economies of equipment, of effort and of time for accomplishing the electric welding are readily recognized and as we all know are readily apparent in great savings in investment and operating costs.

Not alone does the existence of some uncertainty of detailed methods as to how best to accomplish the purpose exist but undoubtedly the large present investment in plant for present gas welding methods, the natural hesitancy to change methods on the part of producers and the reluctance of users to adopt the product of new processes all serve to make the progress a little slower than seems justifiable to those of us that are conversant with the progress of electricity and are not mystified by its multitude of uses and accomplishments. My own conception of the situation is that the electric welding of tubular goods will progress much more rapidly than has the substitution of the gas welding method by the seamless method of making tubular goods in the last twenty years. The growing use of alloy steels, some of which are not readily worked by gas welding and some of which present equal problems to the seamless process will expedite the progress of electric welding as the chemical composition and physical properties of these alloys do not present a similar obstacle to electric welding.

I have not the temerity to discuss the methods now being tried out but I understand much progress is being made and my limited experience with one application of electric welding gives me confidence in expecting much successful accomplishment in the future from the application of electricity to welding in process work in the steel industry

Some Recent Developments in Arc Welding

By K. L. HANSEN*

During the past few years technical magazines, trade magazines and even the daily papers have frequently contained items describing some rather spectacular applications of arc welding. For example, about four years ago the Journal of the Welding Society described a test to destruction of a gasoline cracking still made of steel plates 2½ inches thick arc welded together. Not a weld broke, and before the cast steel head was blown out fibre stresses considerably in excess of sixty thousand pounds per square inch in the walls of the vessel had been reached. The five-story office building erected at Sharon, Pa., by the Westinghouse Electric Company, in which the entire structural steel framework was erected by arc welding instead of riveting, has been the subject of many items of publication. A few months ago one of the Milwaukee papers stated that a Milwaukee firm had in a single day produced the astounding amount of thirty-two miles of pipe, made by the arc welding process. Each of these events marked an outstanding achievement in arc welding at the time of its publication. Again, in the publications of many motor manufacturers we find that one after another has adopted arc welding as the standard process of joining the rotor bars of squirrel cage rotors to the endrings.

All these indications of a sudden and rapid expansion of arc welding may lead us to believe that it is a recently discovered process which industry is now quick to take advantage of. However, such is not the case. Indeed the fact that the electric arc can be used for depositing ferrous material for repair and manufacturing purposes has been known for over forty years. The basic patent covering the now well known carbon arc process was granted to Bernardos, of Petrograd, in 1887, and the patent for the metallic electrode process was granted to Mr. Coffin in 1889. In its early days arc welding obviously met the fate of most useful inventions of having its development delayed by strong opposition which comes as the result of the inherent tendency of the human mind to oppose change, or what may be termed human inertia. However, about fifteen years ago its usefulness began to receive the recognition it deserves, a recognition which has resulted in its rapid development, especially during the last five years.

In the literature of a rapidly developing art there will appear from time to time articles which may almost be considered as milestones indicating the progress of the art insofar as they give a comprehensive resume of the art at that particular time. Such an article appeared about four years ago in the Journal of the American Welding Society. The article was entitled, "Arc Welding as a Manufacturing Process," and was written by Hobart and Spraragen. Referring to arc welding, the authors say in that article, "The material employed should preferably be such as is known to be most satisfactorily welded. Thus, while arc welding is often applicable to joining cast iron parts, the art has not been so highly developed for such a purpose as for welding of mild steel. Experience is rapidly being gained in applying the arc welding process, not only to high carbon steel and to cast iron, but even to special ferrous alloys and to non-ferrous metals, but the great mass of the most important and satisfactory applications relates to the welding of mild steel parts such as steel castings, steel plates and rolled structural steel."

It is unquestionably true today, as it was four years ago, that most arc welding applications relate to welding of mild steel parts. But it is equally true now, as it was then, that experience is rapidly being gained in welding of metals other than mild steel. Because of the increasing importance of these metals to industry, and because they are much less frequently discussed than mild steel, I wish to call your attention for a few minutes this morning to some successful applications of arc welding to alloy steels and non-ferrous metals.

HARD-SURFACING

One of the most conspicuous developments of arc welding of alloy steels has been its rapidly increasing use in making hard surface weld deposits on tools and appliances subject to a great deal of abrasive wear. Testing of weld deposits for resistance to abrasion is not the simple matter that at first sight it would appear to be. Experience has shown that weld deposits which are hard as measured by means of the standard methods of measuring hardness, such as the scleroscope, or Brinell, do not necessarily stand up best in actual service. There are other factors besides hardness which affect the weld deposits's ability to resist abrasion. For example, its ductility and the effect of cold work on the deposit are important factors.

As considerable time is required to test hard surfacing materials in actual practice, and as the standard hardness tests do not tell the whole story, it is, of course, imminently desirable to have a method of producing an accelerated abrasive test which will really reveal something. An ingenious method of doing this has been developed by the Fusion Welding Corporation of Chicago. It is described in the September issue of Fusion News, in an article on "Theory of Abrasion Resistance," by Mr. J. B. Green, President of the Fusion Welding Corporation. It makes use of an air hammer which is arranged to deliver measured blows to the deposit under test. The hammer is calibrated so that the number of foot pounds of energy delivered can be accurately measured. A pad of the deposit to be tested is laid down and a reading taken of its initial scleroscope hardness. The apparatus is then set to deliver blows which from previous experiment have been found to exceed in intensity the elastic limit of the metal under test. By measuring the hardness at intervals, it is possible to plot curves, as in Fig. 1, showing the relation between the foot pounds of

*Northwestern Mfg. Co., Milwaukee, Wis.

energy delivered and the increase in hardness. As the metal becomes harder it loses ductility.

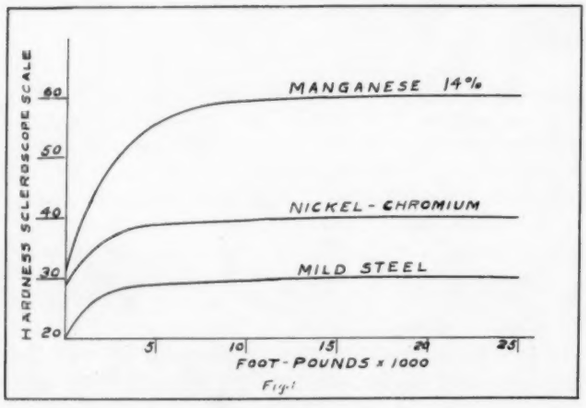

FIG. 1.

However, if it hardens to the extent that the elastic limit in compression becomes greater than intensity of the impact before it becomes brittle, it will last indefinitely. On the other hand, if it loses ductility to the extent of becoming brittle before this degree of hardness is reached, it crumbles and spalls off rapidly. It is this property of hardening to a remarkable degree with cold work and at the same time retain some ductility which makes manganese steel so eminently suited to applications that are subject to severe pounding, such as railroad crossovers, switch points, etc.

In designing welding rods for hard facing, due consideration must, of course, be given to the metal on which it is to be deposited. For example, if a manganese steel casting is to be built up, it is obvious that the rod will contain a large percentage of manganese to give the deposit wearing characteristics similar to those of the original material. On the other hand, if it is desired to deposit a hard layer on a piece of soft steel, carbon frequently plays an important part in the composition of the rod, because of the well-known property of carbon of giving hardening power to steel. However, even in high carbon welding rods other elements are usually present to some extent. Elements used for this purpose include manganese, chromium, vanadium, nickel, tungsten, etc. Some carbon will be lost in passing through the arc and a corresponding loss of hardening power may be compensated for by the presence of such elements. Furthermore, there are many applications where it is desirable to have the hardness of the deposit unaffected by subsequent heat treatment. Other elements predominate over carbon in welding rods designed to give this characteristic.
In general, the composition of the rod must be such that the deposit contains the elements in the desired proportion after the metal has passed through the arc in the molten state and deposited on the parent metal. Quite a variety of hard-facing welding rods for various purposes have been placed on the market in the last few years. To obtain the best results, each rod requires a special technique, and it is best in each case to obtain information from the manufacturer as to the best way to proceed to obtain the desired results.

As an illustration of a welding rod used extensively in building up worn cutting edges of large rock drilling bits, may be mentioned Weldite E—3½% Nickel Steel Electrode. In an application of this kind it is desirable to have an extremely hard surface with a tough backing. A deposit made with the rod mentioned and then case-hardened gives the desired combination. The manufacturer recommends a current of 125 to 175 amperes with a 5/32" rod and 150 to 225 amperes with a 3/16" rod. As laid down with this current the deposit will show a Brinell hardness of 160 to 190.

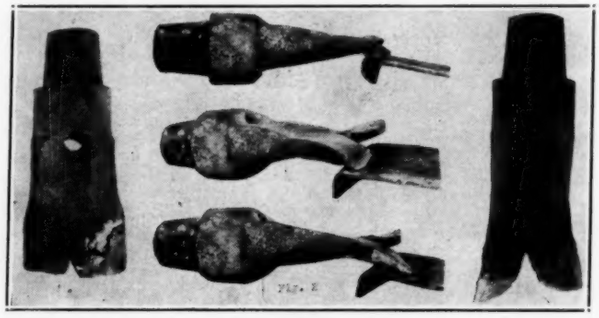

FIG. 2.

Fig. 2 illustrates the building up of the cutting edges of fishtail bits with hard-facing materials. These bits are extensively used in drilling operation in the oil fields. The usual procedure in building up a bit that has come out of the hole is first to clean off all old hard-facing metal on the bit. It is then built up to size with a high carbon welding rod. The high carbon rod used on the bits in the illustration has the following analysis:

Carbon	.60 - .70
Manganese	1.00 - 1.25
Silica	.16 - .2
Phosphorous and Sulphur not exceeding	.04

A 3/16" high carbon rod requires a current from 175 to 200 amperes, and as in almost all alloy steel arc welding, the rod is made the positive electrode and the work the negative electrode. The copper plate shown in the illustration supporting the deposit is a great aid in the building up operation. After the bit has been built up to size, the hard-facing material is applied. The hard-facing rod used in this case was Stoodite. The scleroscope hardness number of a deposit made with this rod is about 70. The fishtail bit is only one of the great variety of types of bits used in the oil fields, and to which hard-facing by arc welding has been applied with great success.

Another field in which hard-facing has been the means of effecting enormous savings is the building up of worn down rail ends, switch points, crossovers, etc., on the railroads. Quite a variety of welding rods are used in arc welding on track work. For instance, one rod used in building up rail ends showed the following analysis:

Carbon	.14	Vanadium	.10	Sulphur	.017
Silicon	.21	Phosphorous	.015	Nickel	5.12
Manganese	.32	Chrome	.10		

It is interesting to note that a deposit made

with this rod on a high carbon rail showed a slight increase in carbon to .21 and manganese to .45, whereas nickel decreased to 3.08 per cent. The Brinell hardness of the deposit varied from 228 to 285 with an average of 258.

A considerable amount of arc welding of manganese steel is being done in connection with railroad work. Manganese steel has the well-known property that when heated to a temperature of 1850 degrees Fahrenheit or higher it must be rapidly cooled by quenching to keep it from getting very hard and brittle. When so treated, however, it is soft and ductile, and as stated, has a great resistance to abrasive wear as well as a high tensile strength. When arc welding it, using a welding rod also containing a high percentage of manganese, it is customary to quench each layer as soon as it has been deposited, keeping the casting cool during the whole process of welding to prevent checking, and to keep the metal from getting brittle.

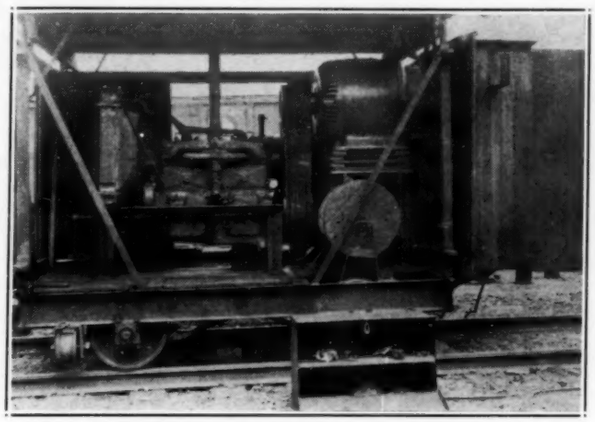

FIG. 3.

It is interesting to note that the trend in track welding of late has been in the same direction as in welding of mild steel, that is toward higher current and larger rods to increase the speed. In Fig. 3 is shown a portable welding plant used by the Chicago, Milwaukee & St. Paul Railroad.

NICKEL CHROMIUM ALLOYS

A number of corrosion resisting alloy steels have been developed and placed on the market in recent years. The attempts to arc weld these alloys have met with varying degrees of success. Some of them are now being successfully arc welded on a production basis.

Fig. 4 shows a 1250 gal. tank in the process of construction in the plant of the Alloy Products Company, Milwaukee. The tank, which is used for transporting and storing of milk, is made of 12 gauge Allegheny metal. The eliptical shell has a circumferential seam in the middle and a longitudinal seam the entire length. The heads are flanged so that the circumferential welds at the ends are also straight butt welds. The welds are ground smooth on the inside. The tank is completely covered with 1½ inch thermo insulation, which in turn is covered with 16 gauge sheet aluminum.

On the extreme right is shown a sample weld, the lower end of which is ground flush. The welding wire used in making these welds is, like the metal itself, a product of the Allegheny Steel Company. Among other elements, Allegheny metal contains from 17 to 20% chromium and from 7 to 10% nickel. It has a tensile strength of close to 90,000 lbs. per sq. inch which, after cold rolling, may exceed 150,000 lbs. per sq. in. Arc welds in this metal will consistently show a tensile strength of approximately 95,000 lbs. per sq. inch and an elongation in 2 inches of approximately 65%.

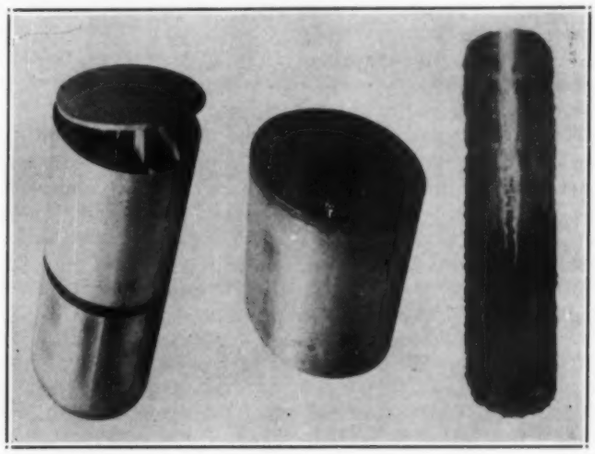

FIG. 4.

NON-FERROUS METALS

About six years ago a committee of the American Welding Society sent out questionnaires to manufacturers of welding apparatus and also to users of the arc welding process, asking information in regard to arc welding of copper, brass and bronze. From the data obtained, a summary was published in the Journal of the Welding Society for March, 1924. The gist of the summary was that some arc welding of copper is being done with the carbon arc and also a slight amount of welding with the metallic arc, using a phosphor copper rod as the positive electrode. It further suggests electrodes of special composition and that a flux be used in making the weld. It states that nearly all the writers answering the question agree that the line of weld should be preheated before welding. With reference to the use of hammering and annealing, there appeared to be quite a disagreement among the experts. Also, in regard to porosity, the opinions differed in that some claimed that the deposited metal is free from porosity, while others claimed that porosity cannot be eliminated. The summary concludes the discussion of arc welding of copper with the following interesting statement: "About the only practical use given in the literature for the arc welding of copper is on the welding of copper bonds to steel rails." With reference to welding of brass and bronze, the summary is still more indefinite and does not mention any practical use, except, perhaps, some little repair work now and then.

In the December, 1927, issue of the Journal of the Welding Society there is a chapter discussing the status of arc welding of non-ferrous metals at that time. The opening paragraph of that chapter reads as follows: "Non-ferrous metals as commercially

used are more or less difficult to weld by means of the electric arc, although some welding is actually done. The application of the electric arc process to the welding of non-ferrous metals is still in its experimental stages." It then proceeds to give substantially the same summary as given four years previously, and concludes the discussion with exactly the same statement, that the only practical use of arc welding of copper is for welding copper bonds onto steel rails. It seems that the Welding Society is not aware of an application of arc welding of copper that has found a very extensive use since it published its summary six years ago. I refer to the use of arc welding of the rotor bars of squirrel cage induction motors to the endrings.

To the writer's notice, at least nine electric motor manufacturers are using arc welding as the standard process in joining the rotor bars to the endrings. The carbon arc is used exclusively in making these welds. It is also interesting to observe that in making these copper-to-copper joints not one of the suggestions of using rods of special composition or flux, or preheating, or hammering and annealing, is used.

ARC TORCH

While satisfactory for making copper-to-copper joints, in construction of squirrel cage rotors, the carbon arc has not been found to be successful when either the bars or the endrings, or both, are of brass. The filler material used in such cases is usually a bronze welding rod of high zinc content, such as Tobin bronze, and the ordinary arc, whether metallic or carbon arc, fails completely when applied to copper alloys having a large percentage of zinc. Tobin bronze has so many desirable characteristics as a brazing material for joining metals of various kinds, that the failure of the arc when applied to it was all the more to be regretted.

In the very early days of arc welding attempts were made to use the flame of an arc drawn between the converging ends of two carbons for welding purposes. All such attempts failed to go beyond the experimental stage because no practical method of directing and concentrating the flame was available.

About a year and a half ago the writer discovered that the control of this indirect arc flame was markedly improved by using two positive carbons and one negative carbon inclined at the proper angle. A method based on this principle was found so satisfactory for joining copper alloys that we decided to substitute it for the ordinary carbon arc, even on copper-to-copper joints. It has been used almost a year and a half for the construction of rotors at the Northwestern Manufacturing Company, Milwaukee, Wis.

Further experiments revealed that a still easier flame to manipulate was produced when the two positive carbons were replaced by one large carbon having a narrow section in the center, giving in effect a double-bodied carbon. In the center of this electrode, that is in the narrow section, there is inserted an aluminum core. The effect of the aluminum core is a marked improvement in the steadiness and concentration of flame.

Metallurgists of the American Brass Company have investigated the quality of deposits made by this method and the following quotation from a publication of that company speaks for itself:

> "Another method of welding originated by Zerner and used more recently by Mr. K. L. Hansen* is that of the indirect carbon arc. The arc is allowed to play between one ½" carbon electrode on the negative side of a pair of ⅝" carbon electrodes on the positive side. The welding is done by the radiant heat from the white hot crater and the soft intensely hot flow or carbon monoxide gas, which at the same time protects the metal from oxidation. By this means good results can be obtained with any of the copper alloy rods. Even the high zinc rods such as Tobin and Manganese Bronze, flow with satisfactory results."

*Developed by Mr. K. L. Hansen, of the Northwestern Manufacturing Company.

Some Recent Developments in Arc Welding

By K. L. HANSEN

Discussion

Harold Trent: One of the points Mr. Hansen brought out was the fact that the fracture of the cast iron occurred shortly beyond the coefficient from the joint. I have always found that to be the result of welding or brazing of cast iron. Is that going to be a permanent condition?

K. L. Hansen: I don't know. I will have to try different ways of putting them together. You see it is only recently, that is since commencing development of the arc torch, that I have become interested in brazing of cast iron. I have before me a publication of the American Brass Company, entitled "Tobin Bronze and Other Anaconda Copper Alloy Welding Rods." On page 3 of that publication are shown a number of brazed cast iron samples that have been subjected to pulled tests. These were made with the oxy-acetylene torch and they also invariably show failure in the iron in the region next to the brazing material, the same as the sample I have here, which was brazed with the arc torch. I have not had a chance to determine whether failure at this point is due to a change in the iron caused by the welding heat, and if so, how much the iron is weakened at this point. If the decrease in the strength of the iron is just sufficient to cause it to break there, but is still only a comparatively small value, it may not be of any great importance. On the other hand, if it appreciably decreases the

strength of the iron in this region, it is of great importance to eliminate this defect. However, as already stated, I am not in position to say how long or how permanent this condition is going to be.

J. C. Cumberland: I should like to ask Mr. Hansen if he feels that the copper tuyeres that are used in the blast furnace could be welded up by this carbon arc flame?

K. L. Hansen: Well, I don't know yet. These are something like copper coolers, are they not?

J. C. Cumberland: They are copper coolers.

K. L. Hansen: I know, I tried them a number of years ago with just the carbon arc and without pre-heating, and I didn't meet with a great deal of success. Now I have an idea that we can produce a metal which is more ductile than that was, and we may be able to prevent it from cracking. That was our difficulty at that particular time. After we had filled up the hole very nicely, almost invariably a fine crack would appear, which was caused by contraction strains of the copper, but I can't tell whether this new arc torch progress will answer that problem or not, because I haven't tried.

J. C. Cumberland: I should like to ask any one in the meeting here if they are at the present time welding these copper tuyeres with the oxide acetylene process with success. Most of them here are steel mill men. They ought to have had some experience in that work.

K. L. Hansen: I think I can answer the question partly at least, because I know of one shop here in Pittsburgh where that has been done, that is the place where we tried it, but they pre-heated them, and that, of course, altered conditions entirely. If you have to go to pre-heating, of course, it can be done. Then I know that the arc torch too will work, but whether it can be done without pre-heating is another question.

J. C. Cumberland: There would be no objection to pre-heating.

K. L. Hansen: Then I think it is safe to say that it can be done all right.

J. C. Cumberland: Coke oven gas is very plentiful in the steel mill.

Charles H. Kenny: Has anything been done in the way of wire-drawing dies?

K. L. Hansen: What do you mean? Building them up and arc welding? That I don't know.

Charles H. Kenny: Lining?

K. L. Hansen: I can't answer that question. One good place to find out would be the Fusion Welding Corporation of Chicago. They are in the business of drawing wire and also in the business of making welding wire and have done a great deal of experimental work in welding. I know they have also solved some difficult problems in wire drawing. Because of its increase in hardness with cold work, chrome nickel wire is extremely difficult to draw. To get dies to stand up in this kind of service has been one of the problems which they have solved successfully.

E. T. Davis: Has any one any questions to ask in regard to the arc welding?

A. R. Welch: May I ask the speaker if any thing has been done with this process of arc welding with Stellite?

K. L. Hansen: Do you mean with this torch? We just merely tried it at the Metals Exposition in Cleveland where we had a booth next to the Stellite Company, and the deposit we made was not quite as smooth as the deposit put on with the oxy-acetylene torch. However, by grinding it off, the deposit appeared to be absolutely sound underneath.

A. R. Welch: Was it better than the old arc process?

K. L. Hansen: Yes. You see, with the old arc process you took up some of the parent metal and it would mix with the deposit. Stellite is put on more as brazing material would be put on. You just heat the parent metal until it just tins with Stellite, which is not a ferrous material. It is entirely non-ferrous, and the taking up of the metal from the parent metal spoils the deposit; at least the Stellite Company recommend the torch for that reason.

A. R. Welch: May I also ask the name of this process?

K. L. Hansen: Of this torch? Well, we are going to market it under the name of the Hansen Arc Torch. We haven't actually put it on the market yet, but the tool itself will have a trade-name.

W. W. Barefoot: We are using Stellite on punches and wheels, and also on web-rods, with very good success.

K. L. Hansen: Of course, I know that Stellite is used very successfully as this gentleman says. The reason why I did not mention it in my talk is because it is applied with a torch, and it is recommended by the Haynes Stellite Company that it be deposited with a torch. It is really not an arc welding application as yet, unless we can make this arc torch work pretty well. Then, of course, it would also be an arc welding application. So far we haven't tried this sufficiently to tell whether or not it will be successful.

J. C. Cumberland: May I ask Mr. Barefoot if he pre-heats the dies and punches afterward?

W. W. Barefoot: Yes.

Charles H. Kenny: How feasible?

K. L. Hansen: That is another question that I can't answer. I have noticed some very successful cutting being done under water wheels with a combination of a torch and the arc, but as to what welding is being done, I really can't answer that question.

W. W. Barefoot: In building up these ring gears which you showed in the picture, what do you lay between those teeth?

K. L. Hansen: That was a copper block.

Charles H. Kenny: You have no cases of adhesion due to fusion with copper filled or puddling of metals?

K. L. Hansen: No, very little. You can take a hammer and knock it off. You see the copper conducts the heat away so rapidly, so that although it may stick, a little blow with the hammer will separate it from the steel.

A. M. Candy: Mr. Hansen certainly gave us an interesting talk this morning, but I was somewhat surprised to hear him tell a Scotch story, because I understand that Scotchmen don't particularly appreciate Scotch stories. Just to substantiate this understanding, I asked a Scotch friend of mine if he had any objection to Scotch stories, and he said, "Yes, we don't like Scotch stories, because they are all at our expense."

Just one question occurs to me in connection with the slides which Mr. Hansen showed, and that is with the Teleweld equipment, in building up the end of the rails there was quite a groove shown between the rail ends down to a certain depth, apparently to about the depth of the deposit, or a little deeper, which was considerably wider than the normal space between the ends of the rails further down. I was wondering why such a large amount of relief was provided at that point.

There is also one other question I would like to raise. Mr. Hansen spoke at some length about various Stoody rods used for building up drilling bits. I have read about some of the harder materials, I believe developed under the name of "borium" or some such name as that. I would like to know if Mr. Hansen has had any experience with that.

K. L. Hansen: I am going to answer the last question first, because I really can't answer the first question. Of course, this borium is a very hard material, also developed by the Stoody Company, and it is a good deal harder than Stoodite. It is made in little pieces and is then set on the bit, and they flow Stoody's self-hardening material around it, but that is also another application that so far has been done with the torch.

That is another field that I want to try with this outfit. We have tried it a little and it looks promising.

Now I believe you said the corner of the rail had been cut off a little more than down below, down in between where the end joins—

A. M. Candy: At the end of the rail.

K. L. Hansen: I see, a straight piece and part way down. I didn't notice it myself. I suppose if it is, it is to get a very good corner, one that will stand up. It is right on the corner of the rails where the rails meet.

Well, I really don't know. I will have to ask the railway engineer. I hadn't noticed that wide gap, so I didn't ask about it. If there are any railway engineers here, perhaps they can tell us.

The Tangible Advantages of Electric Heat Treatment

By WIRT S. SCOTT*

The heating of materials for any industrial heat treating process is a problem in economics. That source of energy which will give the desired results at the lowest overall cost is the one to use, regardless of the kind of fuel, or its initial cost.

The cost of fuel, ("fuel" in this instance, is used in its broad sense, to include also electricity) for any heat treating proposition, is only one of many items entering into costs, but for some peculiar reason the average manufacturer does not consider this to be the case. He does not hesitate to install an expensive machine for processing or fabricating materials, provided the machine will return a reasonable amount on the investment; and in figuring the return, all items such as saving in labor, saving in floor space, maintenance, value of the product, etc., are carefully considered.

But what does this same manufacturer do when in the market for a furnace? Does he analyze each proposition thoroughly in the same manner he would analyze the relative costs, for example, between the operation of a steam engine and boiler on one hand, and an electric motor on the other? If he is in the group of nine out of every ten manufacturers at the present time, he would base his conclusions and decisions on the relative cost of fuel, which is just about as equitable as a decision for power drive being made on the basis of coal cost versus cost of electricity.

It is conceivable that coal may cost more than wood for a particular heat treating process, yet due to certain savings, be less expensive in the final analysis. Likewise fuel oil may cost more than coal, or gas cost more than fuel oil, but the cost of producing the desired product may show the more expensive fuel to be the cheaper one to use, when all items of expense are correctly analyzed and applied against the investment.

The author has had the opportunity of visiting a great many installations, for the purpose of determining definitely and accurately the economic value of electric heating in various heat treating processes. For the most part, a great amount of the information desired was available directly from the books of the company using the furnace, but such data had never been gotten together or analyzed by the user, so that while the user, in every case, was satisfied with the general operation of his electric furnace, or furnaces, he had only a vague idea as to the real economic value. As a matter of fact, in many cases, the users who were included in this investigation, believed electric heating to be more expensive than former methods, due to the fact that, in such cases, each was simply comparing the former cost of fuel against the present cost of electricity.

Electricity for heat treating purposes has a great economic value for a tremendous number of applications. The manufacturers of electrical equipment may be in a position to point out specific applications to certain industrial users, but they cannot do much more than scratch the surface of the total number of possibilities. Each potential user of elec-

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tric heating equipment, or at least each large industrial manufacturer should be able to conduct a survey and make an analysis of operating costs comparable to surveys and analysis made in connection with motive power equipment or fabricating machines.

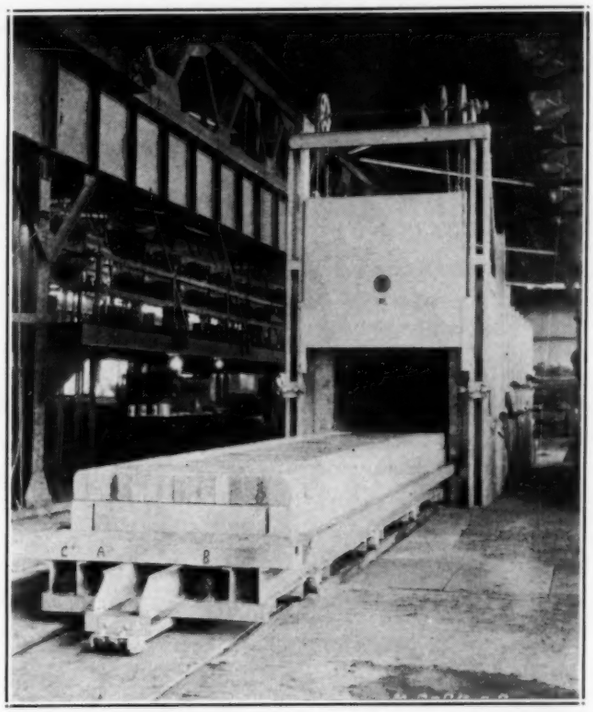

FIG. 1—A 325-K. W. car type furnace for annealing steel bars and rods. The car is 5 feet wide and 25 feet long. Furnace is installed at the Midland, Pa., plant of Pittsburgh Crucible Steel Company.

In order that this subject may be understood some what better than it appears to be at the present time, the results of the author's investigations are presented in the form of a composite investigation, showing the factors entering into costs, and the methods used in arriving at values. These factors and values will vary, depending upon the application, and in some cases, they may not appear at all, while in other cases, the value of one factor or item alone may be 200 or 300 per cent greater than shown. In many cases, the value of some one factor alone was equal or greater than the former cost of fuel.

We will assume a case where an industrial manufacturer is producing 1000 pounds of a completed product per hour. This product, we will assume, may consist of wrenches, bearings, axes, axles, cutlery, shovels, various machines or tools of any kind, in fact, any kind of a finished product requiring uniformity of product, and accuracy in heat treatment. Other data assumed is as follows:

Cost of natural gas per month at 60 cents per 1000 cu. ft.	$ 160.00
Cost of electricity per month at 1.5 cents per k.w. hour	340.00
Sales value of product per month	100,000.00

Quality of Product

With a product selling for $100,000.00 per month, the Sales Expense is assumed to be 25 per cent of this amount, and the Advertising Expense 4 per cent, so we have

Sales Expense,	25% =	$25,000.00 per month
Advertising Expense,	4% =	4,000.00 per month

Suppose that through the installation of improved equipment such as electric furnaces, an improvement in the quality of product is obtainable, also assuming that due to the market conditions, it is not possible to increase the sales price of the product despite the fact the customer is getting more for his money. In what manner can the manufacturer capitalize on this?

A better quality product enables the sales force to hold present customers in line with less effort, also to more easily secure competitive business, thus reducing sales costs. An improved quality gives the advertising department something to talk about. If advertising justifies an expenditure of 4 per cent of the sales value, then an improvement in the quality of product should justify, at least, an additional expenditure of one-tenth of one per cent of the sales value. There is no one thing that will reduce sales resistance, and increase the value of advertising such as a higher quality product will accomplish.

Some may inquire as to what assurance there is that the quality will be improved. The essential elements for the proper heat treatment are:

1. A correct rate of heating.
2. A uniform liberation of heat to the charge.
3. Accurate maintenance of the required operating temperature.
4. A correct rate of cooling.

Electric heating lends itself to these conditions in an ideal manner. Furthermore, all of these conditions may be built into the furnaces and becomes an intregal part of it, not a variable function such as experienced with coal, oil, or gas fuels. Some may say that they have an oil or gas furnace, having automatic temperature control, which controls the temperature within 4 to 5 degrees plus or minus from a predetermined point. That means absolutely nothing. If it means anything at all, it means that the temperature at the thermo-couple is being held constant. The temperature three feet away from the thermo-couple may be higher or lower than the controlled temperature by 50 or even 100 degrees. The author inspected a high grade fuel oil furnace having automatic temperature control, which, as controlled and recorded by high grade pyrometers apparently was giving almost a straight line temperature chart at a certain operating temperature. The thermo-couple for the controlling pyrometer was placed 15 inches from the recording pyrometer thermo-couple, and in order to secure a daily chart of the operating temperature of 1450 deg. Fahr., the control pyrometer had to be set 50 degrees higher. In other words, there was a difference in temperature within a space of 15 inches of 50 degrees. A calibration of the instruments showed that the pyrometers were accurate.

In an electric furnace, it is possible to locate the heaters so as to give a uniform liberation of heat to the charge, and once this condition is attained, it is fixed, and not subject to change or variation. The temperature condition of the electric furnace is an inherent part of the design. If, within a definite

working space within a furnace chamber, the liberation of heat to the charge is uniform, and in addition, the temperature as a whole is maintained constant within narrow limits, it is evident that the product will be better than if heat treated in a furnace that does not liberate the heat uniformily to the charge, but which may control the temperature at a given point within close limits.

For improvement in quality, a value of one-tenth of one per cent of the sales price is assumed to be a conservative figure, representing a value of $100.00 per month.

FIG. 2—Two pit type furnaces, 80 K. W. each for annealing wire. Each furnace is 48 inches in diameter by 48 inches deep. This installation is at Carpenter Steel Co., Reading, Pa.

Dependable Production

Where a high grade product is being obtained, using oil or gas furnaces, it is done at the expense of rejections in the heat treatment, and the better the product required, the larger the percentage of rejects. Since the rejects are not constant and may vary from 15 per cent on one day to 35 per cent the next day, no accurate prediction can be made as to the date for the completion of an order. If such rejects can be eliminated, or reduced to a negligable figure, it will be possible to predict with accuracy just when the material will be available after heat treatment. This knowledge, plus the value of time lost, may be worth several hundred dollars each month. For this item, a value of $10.00 per month is being allowed.

Less Stocks In Course of Manufacturing

A reduction or elimination of rejects will result in less stocks and less materials on the floor. The capitalized value of this is set at $50.00 a month.

Decreased Floor Space

Due to the heating chamber of electric furnaces being maintained at a much more uniform temperature than is possible with oil or gas, a better utilization of the space is possible. An elimination of rejects due to heat treament also permits less equipment being used. It is evident that if the rejects amount to 25 per cent, that 25 per cent additional equipment must be available, since the total amount heat treated each day would be 125 per cent of the finished product. A value of $25.00 a month is allowed for decreased floor space.

Decrease In Labor for Hardening and Tempering

In practically every case where electric furnaces are used, a substantial reduction in labor costs have been made. Fuel furnaces require skilled operators, whereas with electric furnaces, heat treatment becomes a relatively simple operation, a matter of timing, rather than watching the furnace and the product. In most cases, a reduction in labor costs of 50 per cent have been accomplished. With a labor charge of $600.00 for the natural gas furnaces, a charge of $400.00 will be taken for the electric furnaces, or a saving of $200.00 a month on labor for heat treatment.

Decreased Inspection and Testing

With the elimination of rejects, the amount of inspection and testing may be reduced to a minimum. For a similar production as shown, one manufacturer dispensed with two men, or a saving of $200.00 a month. A saving of one man at $100.00 a month will be used in this analysis.

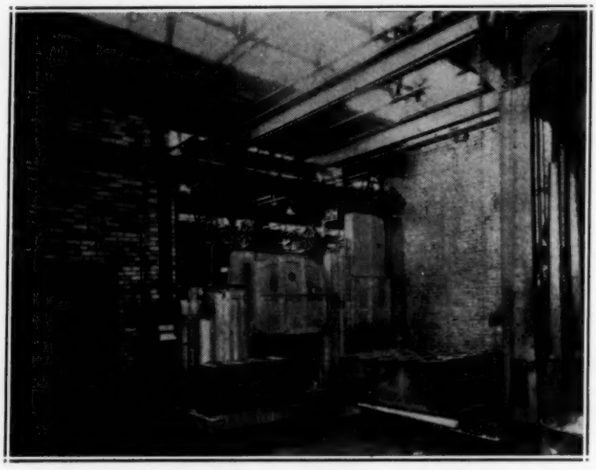

FIG. 3—An 80 K. W. recuperative type furnace installed at Cincinnati Milling Machine Company for carburizing of bar steel. The heating chamber is 48"x72"x 33" high. The double deck recuperating chamber is shown on the right.

Decrease In Labor After Heat Treatment

This is one of the most important items, and usually one not considered at all. In one case, where a large amount of drilling and machining had to be done on forgings, the savings in the tool department in broken tools, labor, and increased production amounted to over $1,000.00 a month, with a fuel cost of approximately $300.00 a month. For this item, a saving of $100.00 a month is allowed.

Saving In Labor of Starting Up Furnaces

In starting up a fuel fired furnace each morning, it must be some one's job to light the burners, and give a certain amount of attention to the furnace while heating up. Usually some one is delegated to come on duty from two to three hours earlier each morning to take care of these duties. The cost of this in a similar case was actually $42.90 per month. With electric furnaces, a watchman on his rounds

can perform the entire requirements by the pushing of a button. Even this service may be dispensed with through the installation of time clocks which may be set to turn on the current at any predetermined time. The saving for this item is figured at $25.00 per month.

Better Working Conditions

There is a value attached to the improvement in working conditions, otherwise industrial plants would not have welfare and relief departments. The elimination, or reduction in labor turnover can be accomplished in a large measure by better working conditions. Various plants have placed values on the improvement in working conditions due to electric furnaces, varying from 8 per cent to 12 per cent of the salary. In other words, increasing the salary 8 or 10 per cent would not accomplish as much towards reducing labor turnover and better morale, as the installation of the electric furnace has done. A value of 5 per cent is allowed on the basis of $600.00 a month, or $30.00.

Value of General Operating Characteristics of Electric Furnaces (Ease of Operation)

The more time a workman can devote to production and the less time to the "where-with-all," the more efficient he will become, and actually, the greater amount of work there will be turned out. One company reported a valuation of $50.00 for this item since installing electric furnace. A value of $20.00 per month should be a conservative figure.

Less Handling of Materials

Electric furnaces may be placed directly in line of production or at any point of greatest usefulness, irrespective of surrounding conditions. Electric furnaces are even placed in rooms with girls working all around them. The saving in labor due to less carting or trucking of materials, plus the decreased handling due to elimination of rejects may represent the services of one, or two men. A saving of $75.00 a month is allowed.

Operation of Ventilating Equipment and Blowers for Furnace—Oil Pumps, etc.

For every gallon of fuel oil burned, there is an additional charge for pumping the oil, atomization, and interest charges for oil storage, of 3 to 4 cents. For gas fuel, a blower must be used for supplying air for combustion, which in this case, would cost approximately $7.50 per month. A ventilating fan to remove the gas fumes and heat would cost about the same amount per month, making a total charge of $15.00 per month.

Reductions In Accidents

Using electric heat, many hazards to the workmen are automatically removed. Men are less apt to be burned. A combustible fuel is a hazard at all times. Workmen appreciate this, and in lighting burners or in adjusting them, consume more time than is actually required by the operation in safeguarding themselves. As one manufacturer stated, "His workmen insured themselves at his expense." Electric light bulbs and windows soon become coated with carbon dust from fuel furnaces, one reason why rooms containing such equipment are dark, poorly lighted, unkempt, and have a great amount of junk or other materials not being used, lying around on the floors, for some one to fall over.

Based either on time saved by workmen, or strictly as an insurance premium, this feature is worth at least $2.00 a month.

Reduced Fire and Explosion Hazards

Fires seldom happen, nevertheless every company carries insurance. But insurance is not carried against loss in profits due to loss in production should there be a fire or a serious explosion. In dealing with an explosive fuel, it must be admitted that there is a hazard involved. The elimination of that hazard, in using electric heat, should be worth $5.00 a month, which may be charged off as a special premium on insurance, but credited to the electric furnace.

Reduction In Maintenance

It was found that in every case investigated, that the maintenance on the electric furnace was anywhere from one-half to one-tenth of that of the fuel furnaces. A saving of $30.00 a month on maintenance could very conservatively be expected for the equipment necessary for this proposition.

Reduced Scrappage of Materials

In many operations, defective heat treatment will not show up entirely under the regulation tests given immediately after heat treatment. The tool or part heat treated may be completely fabricated before such defects are determined. In many cases, the heat treatment may be the final operation, except polishing, and a test is given, which, if the part does not stand up under it, the product becomes a total loss.

In our plant, this loss, now reduced to zero, had been $100.00 per month; in a second plant $200.00, and in a third $250.00. A value of $25.00 a month is placed on this item.

Reduced Field Expense, or Reduced Free Replacements

The free replacement of defective tools or parts, after being sold and in the hands of the user, becomes a very expensive proposition at times. Some products may require the services of a field representative to make the necessary repairs. One company reports that since installing electric furnaces, their free replacements for all causes had been reduced 20 per cent; a second company a saving of $3,000.00 a year; a third company a saving of $8,000.00 a year. With such savings being made, an assumed figure of $75.00 a month would be considered quite conservative.

Value of Improved Shop Appearance

Electric furnaces give off no dirt, smoke or fumes, makes no noise, gives off very little heat, are pleasing in appearance, do not get dirty except through the usual amount of dust that collects in any shop, and are one of the strongest factors in promoting cleanliness on the part of the workmen. As a rule, workmen naturally take pride in keeping machines clean which do not, in themselves, create dirt.

Aside from the effect on the workmen, what will electric furnaces be worth to a manufacturer every time his heat treating department is visited by a customer? What would it be worth to him to have

his customer visit the heat treating department where electric furnaces are being used, and have no heat, no noise, with the ability to converse without hollering, no fumes, no dirt, with everything going along quietly and with machine-like regularity? Almost any manager would be willing to appropriate $5.00 from his entertaining expenses, towards having such a condition solely for the impression it would make on a prospective purchaser. A value of $5.00 a month is being allowed under this item.

SUMMARY

		Monthly Savings
Item	1. Quality of Product	$100.00
"	2. Dependable Products	10.00
"	3. Less Stocks in Course of Manufacture	50.00
"	4. Decreased Floor Space	25.00
"	5. Decrease in Labor Costs for Hardening and Tempering	200.00
"	6. Decreased Inspection and Testing	100.00
"	7. Decrease in Labor after Heat Treatment	100.00
"	8. Saving in Labor of Starting Up Furnace	25.00
"	9. Betterment of Working Conditions	30.00
"	10. Value of General Operating Characteristics of Electric Furnaces	20.00
"	11. Less Handling of Materials	75.00
"	12. Operation of Blower and Ventilating Equipment	15.00
"	13. Reduction in Accidents	2.00
"	14. Reduced Fire and Explosion Hazards	5.00
"	15. Reduction in Maintenance	30.00
"	16. Reduced Scrappage of Materials	25.00
"	17. Reduced Field Expense, or Free Replacements	75.00
"	18. Value of Improved Shop Appearance	5.00
	Total gross value per month	$892.00
	Difference between electricity and gas cost	$ 180.00
	Net savings per month	$ 712.00
	Net savings per year	$ 8,544.00
	Cost of equipment installed	$12,000.00
	Return on investments	71%

While a return on any investment of over 71% is exceedingly profitable business, yet this represents but an average condition as found, after a thorough analysis of all tangible items entering into costs. As stated in the foregoing, the cost of fuel is only one of the items entering into costs. That source of energy which will give the desired results at the lower overall cost is the one to adopt.

Uses of Electricity in the Development and Manufacture of Tool Steel

By O. K. PARMITER*

On no other industry has electricity exerted a more powerful influence than on that of tool steel. Modern methods of melting, rolling, heat treating, inspection and handling are possible only through the medium of electricity. In many of the various phases of tool steel manufacture where accurate control is of vital importance, it has eliminated the "human element" and replaced it with "automatic control." Temperatures ranging from below the freezing point of water to above the boiling point of steel are today accurately regulated and controlled with the utmost ease by electricity. The far-reaching effect of this "temperature control" alone upon standardization and quality in tool steel is so great that it can scarcely be conceived.

Melting By Electricity

The advent of the electric arc melting furnace some twenty odd years ago was revolutionary in its effect upon the steel industry. It came at about the same time that High Speed Steel was being developed from an inconsistent alloy into a practical, commercial product. The electric melting furnace made High Speed Steel possible as it has also made possible the production of that other complicated alloy, Stainless Steel. In the manufacture of High Speed Steel, costly alloying materials such as Tungsten, Chromium, Vanadium, Cobalt and Molybdenum are introduced into the steel. The melting temperature or point of solution of these elements is unusually high. Before the advent of the Heroult melting furnace, manufacturers of alloy steels containing such volatile and easily oxidized elements had been compelled through necessity to melt their product in the crucible furnace with its associated high costs and other objectionable features. The electric melting furnace has opened up a new field with many interesting possibilities.

The development of the electric arc furnace and its adaptation to the melting of alloy and carbon tool steel was not accomplished over night. In the beginning, serious obstacles were encountered and many disappointments came to pioneers in the work. Of recent years, considerable progress, especially in the way of automatic control and mechanical manipulation, has been made. So great has been this advancement in the last few years, that electric furnaces are practically eliminating and replacing the gas fired crucible furnace for all alloy steels. Some of the more im-

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portant of these advantages are included in the following:

Advantages of Electric Melting

1. Greater uniformity in chemical composition over a long run of consecutive heats. Volatile and easily oxidized alloys, such as vanadium, molybdenum, silicon, manganese and chromium, can be held closer to required limits than by any other method. Better control of heat treatment is possible because of this more uniform composition.

2. Electric furnace steel is purer chemically than any other steel. There are less oxides produced by this method of melting, and, therefore, less of them to be removed. Irrespective of whether or not uniformly distributed sulphur is as harmful as is generally believed, it is obvious that segregation of elements is impossible if they are absent. Low sulphur in electric furnace steel usually indicates a prior reducing condition favorable to complete deoxidation, sound ingots, freedom from blow-holes and resulting seams.

3. Any alloy additions may be made in the furnace itself rather than in the ladle, which increases the probability of thorough assimilation and diffusion. All of these characteristics tend toward the production of a steel of better quality.

4. The electric melting furnace also possesses an economic value in its adaptability to the recovery of costly, volatile alloys contained in scrap.

Electric Operated Controls

Mechanical features of the modern electric arc furnace include automatic control of the electrodes and electrically operated tilting devices. The automatic regulators properly adjust the electrodes thus accurately controlling the current input and temperature. The automatic control not only results in a saving in current and electrode consumption but provides a fixed melting time at a uniform temperature. Special electrical devices facilitate skimming and manipulation of the slag, also the making of repairs to the furnace lining. Mechanical tilting, electrically controlled also furnishes a means of teeming whereby the volume and pressure of the stream of molten steel is under the operator's control. In some installations, suitable transformer taps provide comparatively high voltages for rapid melting, intermediate ones for slower melting, and relatively low voltages for refining. Such practice not only results in increased production and lower current costs, but prevents overheating of the molten steel at a time when such an occurrence is highly detrimental.

In preparing a crucible or open hearth furnace for melting, several weeks of slow and careful heating is necessary to insure a long life of the furnace lining and the refractories in the regenerative chambers. Once a furnace of this type is heated, the operation becomes a continuous one and by necessity remains so as long as the refractories hold up. Electric furnace melting is not hampered by such objections. Melting may be interrupted and resumed at any time without additional costs for upkeep during the time which the furnace was idle. The roof of the ordinary electric arc melting furnace is removable and in making repairs may easily be replaced by a new one in a very short time. Other repairs can be made in much the same manner.

High Frequency Induction Furnaces

The latest development in electric melting is the high frequency induction furnace. This furnace in the opinion of experts is the beginning of the most important advance that has ever been made toward obtaining purity and quality in high grade steel. With this particular type of furnace, vacuum melting of steel on a production basis is not far distant. Removal of oxides, gases and solidification difficulties by such vastly improved practice will eventually give to us cleaner, better steel, free from inclusions, blowholes and segregation. To Dr. Edwin F. Northrup of Princeton, N. J., is due the honor of having invented the high frequency crucible furnace described in the following paragraphs and of having adapted it to commercial practice.

The principle of this high frequency furnace is that of an air transformer, whose primary is the furnace coil and whose secondary is the melt or the conducting crucible containing the melt. The primary is merely a helical coil of copper tubing through which water is passed for cooling. If high frequency current is applied to the terminals of the helix, all the space inside the coil is subjected to a rapidly alternating electro-magnetic field. Any electrical conductor placed in this magnetic field will have currents induced in it. These induced currents cause rapid and efficient heating.

Near the terminals of the inductor which consists of water cooled copper tubing, is connected the source of high frequency current. The water flows through the inductor coil, entering at a middle point and leaving by outlets at each end of the coil. Directly inside this coiled copper tube inductor is placed a thin sheet of micanite for electrical insulation, and between this micanite and the crucible is packed fine silica sand. This sand provides heat insulation and also backs up the crucible in case of leaks or abrasions. A refractory crucible, sometimes used for carbon-free melting of steel is made of moulded silica sand. When it is desired, the crucible can be omitted and the sand refractory made to serve as both crucible and heat insulation. Acid, basic, or neutral linings can be used readily as desired, and they can be very quickly repaired or replaced.

A motor generator set furnishes the high frequency current necessary for furnace operation. Motors for such sets operate from standard voltages and frequencies such as are found in all plants. The generated current varies in voltage and frequency depending upon conditions and melting requirements. The installation which we have in use operates on 900 volts at a frequency of 960 cycles.

Some of the outstanding features of the high frequency furnace for melting tool steel include freedom from contamination, excellent mixing action and ease of temperature control. There are no arcs or carbons required in the equipment, therefore there is complete freedom from electrode contamination. In the remelting of high chromium steel, commonly known as Stainless Steel, it is of a great advantage to be able to do so without the usual associated chromium loss and carbon contamination.

Inherent in the furnace is its stirring action. The electro-magnetic forces cause the metal to rise along the axis of the charge and to descend along its cir-

cumference. Segregation is practically impossible. This feature is of great value in the melting of steels of high alloy content, especially when the alloying materials vary considerably in specific gravity. The power input to furnaces can be controlled at will, so that the steel may be melted slowly, rapidly or held quiescent. It is possible to arrange the furnace in almost any size so that the steel may be melted under vacuum or controlled atmosphere.

Electrically driven Rolling Mills

While practically all of the tool steel mills have electric melting furnaces in operation, only a comparatively few have as yet recognized the economic value and wide adaptability of the modern electrically operated rolling mill. For some time, large manufacturers of tonnage steel have been taking advantage of the economy and flexibility made possible by the electric drive. Much progress has been made on heavy production mills, a large number of which are in satisfactory operation today.

Rolling tool steel is considerably more of a quality proposition than that of tonnage steel. While quality is the first consideration, production is highly desirable; both are possible with the electrically driven mill. Again, as with practically all electrical apparatus, the flexibility of control is the foremost feature of such mills. Independent drive, unhampered by other operations on the mill, increases the efficiency of the finishing stand. Variable speed motors operate to give the desired mill conditions at any time, either on the breakdown or finishing stands. Exact speeds, predetermined as necessary for certain steels and rolling temperatures, may be had in the fraction of a minute. Accurate instruments in plain view show speeds and power being consumed in such a way that the roller knows his mill conditions at all times. Trouble may be detected without difficulty. This ease of operation and close control is also of considerable value from a safety viewpoint. Safety switches are usually provided for emergencies on each stand where they may be reached instantly. In such cases, dynamic braking makes quick stops possible.

A smooth, well finished surface is obtained with the electric drive, as there is no chance of backlash from gears. Overloading to a reasonable degree does not appear to affect well designed rolling mill motors. Due to the flexibility and reserve power of the motor drive, a higher delivery speed is possible. The stands are usually relatively close together and the whole installation is quite compact. Light strip material and wire can be handled faster, due to this conservation of space, thereby retaining the proper rolling temperature for a longer time.

Electric Heat Treating Equipment

Within the past few years, industrial electric heating apparatus has been successfully developed and applied to practically every heating operation in the manufacture and heat treatment of steel. Electric heat is giving entire satisfaction in all the various branches of heat treatment of tool steel, whether it be in annealing, normalizing, hardening or drawing operations. It is particularly valuable where exact controlled and duplicate heating conditions are demanded. In practically every case where modern and properly designed equipment is used, this electrical method of generating, distributing and controlling heat has proved capable of turning out a product of higher quality than is possible with any other form of heating apparatus.

Electric furnaces of every type and description are available for various heat treating operations. They range in size from those used in the hardening of delicate watch parts to those employed in the treating of oil refining stills. Furnaces for this latter application are enormous in size, being capable of housing a large size locomotive. Such a furnace is rated at capacity of 3000 K.W. and contains more than a mile and a half of resistor material. Not only do these heat treating furnaces vary in size and capacity, but dozens of distinctly different types, from a mechanical standpoint, have been developed.

Most of the heat treating in a tool steel mill may be considered under the general term of annealing, which, broadly speaking, may include normalizing and high temperature drawing. Some steels respond quite readily to wide ranges of treating temperatures. Others, of the more complicated alloy variety, are so sensitive that a difference of a few degrees in drawing or annealing temperature may result in entirely different physical properties. Users of tool and alloy steel insist upon unusually narrow ranges of hardness and strength, and the manufacturer is obliged to meet such specified requirements. There must be no variation outside the range of the specification. Every portion of every bar must fall within the narrow range or be rejected. Without the modern electric furnace in its present degree of devlopment, such specifications would be ridiculously impractical.

Automatic zone control has solved the problem of obtaining uniformitv in sensitive steels. The furnace for annealing such steels is divided into one middle and two end zones. Each zone is connected to a phase and each phase is independently and automatically controlled through suitable thermo-couples and controlling devices. Variations in bar length and volume of steel in the end zones are thus automatically taken care of. The time of heating, holding and cooling is under absolute control, as the control may be adjusted to any time cycle as desired. The on and off current period is controlled over the narrow margin of plus or minus 10° F. on heating and plus or minus 5° F. when the steel is at heat.

Furnaces for hardening and tempering are heated and controlled in much the same manner but, usually being comparatively small, the problems encountered are not so difficult.

Electricity in the Chemical Laboratory

In the steel works laboratory and inspection departments are found some very interesting electrical apparatus which is used to determine chemical composition and to disclose physical and structural defects. Electrically heated combustion furnaces, muffles and hot plates, as well as electrically operated sampling devices, shakers and grinders, have become so useful and common that they are considered an essential part of modern laboratory equipment. One of the most positive methods known for the determination of certain metals is that of electrolytic deposition. Electro-metric titration is possibly the most useful and accurate method of de-

termining values by volumetric analysis. Motor-driven testing machines are used in working out the physical properties of steel, while electric metallographic apparatus is employed in examining its structure under high magnifications.

Within the last few years, new methods of inspection made possible by electricity include Magnetic and Spectrum Analysis. Both methods are entirely practical from a commercial viewpoint. Their influence on quality and uniformity opens up a new field of research.

Electro-Magnetic Analysis

During the process of Magnetic Analysis, the steel bar which is being tested is passed through magnetic coils. Either alternating or direct current may be employed, but methods utilizing the magnetizing action of alternating current are probably the most satisfactory. A. C. current makes possible the use of an oscillograph as a calibrating and recording instrument. By this means, the properties of the steel can be analyzed magnetically and correlated with the composition and physical properties. All of the changes or differences in a bar of steel as it is passed through the equipment become visible and are recorded on the oscillograph in the form of curves or oscillograms. One of the most important and recent advances in the process is the fact that any volume or size of defect may be used as a separating point between good and bad material, thus eliminating the erroneous idea that has existed in the past, that Magnetic Analysis is too sensitive to be practical. The effect of human element has been reduced to a minimum, as all of the work is done by instruments. This adds much to the merit of the process.

Defects disclosed by this method of testing include cracks, seams, non-metallic inclusions and segregations which are present either in the internal or external portion of the bar. Strains and slight internal ruptures can be noted, as well as variations in grain size and hardness due to improper heat treatment. Magnetic Analysis has many advantages over other methods of testing steel for uniformity. The fact that the material being tested is not destroyed or injured in any way is of particular advantage and, again, the method is so accurate and rapid that every bar of a whole lot may be tested instead of a low percentage of test pieces considered representative.

Spectrum Analysis

Spectrum Analysis as applied to industrial chemistry in the modern laboratory has also been of great assistance in working out problems of an analytical and metallurgical nature. Qualitative analyses not at all possible by ordinary means can be made without any particular effort by this method. A fraction of a gram of material will usually suffice for spectographic analysis. In making the determination, the metal or alloy to be tested is used as an electrode to form an arc with direct current. A ray of light resulting from the arc produced is passed through a series of lenses and a suitable prism, usually of quartz glass, and is reflected on a special screen. The image produced is known as a "spectrograph," and may be photographed for a permanent record. The instrument employed is known as a "spectroscope" and the photographic record as a "spectogram." In every spectrum there are groups of lines which are highly characteristic of the metal being studied. Such spectra are used as standards of comparison in determining the presence and amount of the element under test. The effect of very small amounts of the rare elements upon the properties of tool steel, which is made possible by this method, forms a most fascinating study.

Cemented Tungsten Carbide

The most recent development in materials used for cutting hard substances, and one which is destined to have a revolutionary effect upon the tool steel and machine tool industries, is that of cemented tungsten carbide. Tungsten carbide is an intensely hard metallic substance, and is a product of the electric furnace. It may be produced either by melting or by sintering. The material produced by fusion is relatively brittle and cannot be used for cutting metals, while that which is powdered, compressed and sintered possesses sufficient toughness and exceptional cutting properties. Cemented tungsten carbide is made in specially designed electric furnaces having an alundum tube muffle wound with molybdenum wire and surrounded with magnesite, through all of which a hydrogen atmosphere is maintained. The various operations in its manufacture require unusually narrow temperature ranges. The close control necessary, considered for a time as only a laboratory possibility, has become entirely practical from a production viewpoint through the proper application of the electric furnace and its associated control.

More improvement has been made in tool steel in the last quarter of a century than in all time prior to that period. During this comparatively short time, we have witnessed three outstanding developments, which include High Speed Steel, Stainless Steel and Cemented Tungsten Carbide. None of these valuable materials, so necessary to modern progress, could have been developed to their present degree of usefulness without the assistance of applied electricity, and yet, in closing, I wish to say that it is my firm belief that we are only at the beginning of the possibilities of electricity as applied to the making of steels of the better quality.

SPECIAL FEATURE—PHILADELPHIA SECTION

SATURDAY, APRIL 5, 1930

"SOME APPLICATIONS OF FUSION WELDING TO THE MAINTENANCE OF ELECTRICAL EQUIPMENT IN THE STEEL INDUSTRY."

By John C. Reed, Electrical Engineer, Bethlehem Steel, Company, Steelton, Pa.

Electric Welding of Heavy Materials

By J. F. LINCOLN*

The application of arc welding has been almost entirely along two lines:

First:—Repairs on all kinds of metal parts.

Second:—Manufacturing.

There is very little to be said in connection with the repairs. This was the first application of arc welding and is undoubtedly the one which had more to do with giving it a reputation than anything that has happened since. The repair of the interned German boats in 1917, which had been broken up by their crews, is an outstanding example of what can be done with this tool, and probably this experience went a long way toward acquainting the people of these United States with this process.

The greatest application is in the manufacture of new parts by the use of arc welding. Here the welding takes the place of either rivets or the joining of structural parts into shapes which replace castings. While there is no doubt that the riveted construction will be entirely replaced by welding (and particularly will this be true in buildings which are now practically universally riveted), yet this application is relatively small when compared to the greatest known application, and that is the replacement of castings with arc welded steel.

There are between six and seven million tons of castings made in this country each year. If we believe that 85% of these can be replaced with arc welded steel and that the average replacement structure will be half the weight of the cast part, then we can see that there will be an increase in consumption of between two and one-half and three million tons of steel. This is a new market and is undoubtedly the greatest potential market now in sight for the steel industry. The fact that they have so far done very little to exploit this market is rather remarkable. They spend a considerable amount of money to exploit other markets where the returns cannot be anything like as great, but this market, which is undoubtedly the greatest potential market now in sight, has strangely been left alone and whatever progress has been made in that field has been largely made by the welding manufacturers. In this work the backing and help of the steel industries would undoubtedly change the complexion of the matter in a very short time.

The objections urged by the manufacturers who are now using castings or rivets and who consider the use of arc welded steel to replace their present methods, are the following:

First: The doubt as to the comparative appearance. The feeling is rather general that for some reason a part made from structural steel will not look as well as a part made from cast iron. It is of course true that the part will look differently, the reason for this being that in the case of the steel the shape will be made so as to give greatest strength and least weight, while in the design of a cast part the main idea that must be in the minds of the designer is to make a shape which will readily draw from the sand in molding. These parts also will have no sharp corners or under-cutting, since this will introduce difficulties in molding which will interfere with its success. The shape of the casting also must to a large extent be dependent upon the shrinkage stresses so that the finished part is not one in which its strength and rigidity are the main considerations as would be true if made of steel.

Second: There are very few men who feel that they know sufficient about welded steel design to use it to best advantage.

Third: The third reason why welding is not more rapidly used is our hesitation to do something in a new way. We are after all a very conservative race in spite of the fact that we like to brag about our open mindedness and our desire to go ahead rapidly. Much of our reputation for progress is dependent upon a few rather outstanding examples and not on the actual policy of the average designer and manufacturer. We still insist that if a boiler has more than 15 pounds pressure in it, it must be riveted, but if the pressure and temperature gets so high that the rivets won't hold, we then weld it as is true in oil cracking stills.

We still insist on having a high pressure boiler riveted, but when we make the super heater into which this steam goes from this high pressure boiler, then because of the high temperature we find it must be welded and weld it we do.

We still insist that a tank car must be rivited but the tank into which the tank car is emptied is almost universally welded.

We still insist that a locomotive frame must be cast steel because of the tremendous shock to which it is subjected, but the gun carriages for our army are all welded, this in spite of the fact that the shock is probably the greatest to which any structure is subjected.

It is much easier for the average designer to do as he has done rather than to acquire the knowledge and facts which will make it possible to take the next step forward. Unless the executives at the head of business will take advantage of this new tool, its advent must be slow and painful.

Fourth: The fourth reason that is generally urged against the use of arc welded steel to replace castings is the fact that frequently the executive feels that a change as radical as this will entirely upset his manufacturing methods requiring new buildings, new machinery, new organization and new technique—as a matter of fact, this is largely unfounded. In general, the new process will require very much less space both for the operation and for storage of finished, semi-finished and raw material. The teaching of his organization will be an easier matter than to teach them the use of almost any new tool. The same organization in general who can succeed with present day manufacturing methods can adapt this new method with great rapidity. As a matter of fact, the following is the experience of almost every manufacturer who has used welding—he first will start to use it only after a great deal of pressure has been put on him

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and only then when he finds some particular job which cannot be done easily any other way. He will start to weld this particular job, find that he succeeds at it and immediately will go to the other extreme, wanting to weld everything in sight. It is a safe thing to say that in every plant where welding is being used, the department which is always under-machined, the department which is working overtime, and the department which is taking on new work most rapidly, is always the welding department.

This new development will make a fundamental change in all manufacturing industry which has to do with iron and steel. It will have the most far-reaching effect of any manufacturing change which this generation has seen. It is the greatest cost-reducing agency which has been conceived since the inception of mass production. Here is one of the greatest challenges and opportunities that the American manufacturer has ever had. The ones who first make use of this new tool will profit most.

I do not know of any body of men to whom this gospel should appeal more strongly than to the steel manufacturers. The greatest opportunity which has ever been presented to this industry is before it in this way. There is no way that the welder manufacturers can force them to take advantage of it—undoubtedly, eventually welder manufacturers will do this job, but it is not customary in this day of tremendous competition to see a field of such great promise lie fallow so long.

Electric Welding of Heavy Materials

By J. F. LINCOLN

Discussion

J. O. Keller: I want to take this opportunity of thanking Mr. Lincoln for his very fine talk. I am sure that he has given us material to think about both interesting and instructive, and has shown us something of the opportunities for the use of welded steel in place of iron castings.

The meeting is now open for discussion or questions, just as you gentlemen see fit. We had some very interesting discussions this morning.

L. R. Foust: May I ask the speaker if in the case of large welded pedestal machine frames they find it necessary to anneal after welding?

J. F. Lincoln: Annealing is unnecessary in general in work of this kind.

D. L. Strausser: In the replacing of steel castings, what proportion do you find it necessary to use? You have shown it takes so much less rolled steel to replace cast iron castings. I have in mind some cast steel wheels. What proportion of rolled steel would we have to use?

J. F. Lincoln: In general it requires about one-third as much steel as cast iron for the same strength. In the case however, of replacing cast steel, the proportion of rolled steel necessary would certainly be as great so there would be no saving in weight.

W. W. Barefoot: What grade of steel would you use on structural steel for welding?

J. F. Lincoln: You are, I infer, speaking of what grade of electrode would be used for structural steel welding. Any of the usual mild steel wires are entirely satisfactory if the proper size of wire and proper amount of current for the work in hand is used. There is practically no difference between the results obtained by various welding wires insofar as the metal in the electrode itself is concerned. The variation in the operation of the arc with various electrodes has practically nothing to do with the metal in the electrode itself. This is controlled entirely by what the covering on the outside is, whether this covering be invisible as is the case with the mill drawn wire, or if it be a very evident coating such as is put in on processed electrodes, in either case the results are identical except insofar as the coating may be a good one or poor one for supporting the arc.

J. O. Keller: Is there any other discussion?

There was one subject this morning in relation to welding that I am sure a lot of people wanted to hear about and mention being made of the name of A. O. Smith made me think that I might ask for discussion here, and see if any of those attending could contribute something on the question of pipe welding. I believe that Mr. Hansen's company has had some experience on that. I should like to ask him to give us a word or two. I realize that this is a subject that no one likes to speak about, because they feel they know very little about it right now. Yet I think that it is just the kind of a subject, that it is a good thing to bring up in a conference such as this; so I am going to ask Mr. Hansen if he will just say a word on that, and then I can ask Mr. Lincoln. Then we shall ask everybody to contribute, because I know there are many persons present who have had some experience along that line.

Would you be willing to say a word or two, Mr. Hansen?

K. L. Hansen: I don't know that I have anything to say regarding pipe welding, except that we furnished 194 eight hundred ampere welders for the pipe plant of the A. O. Smith Corporation, and that is an awful lot of energy going into the welding of pipe, and when the production is up to an average of 26 miles a day and has reached as high as 32 miles a day, with about a 24-inch pipe, that is doing a lot of pipe welding. Now, I haven't been inside of that plant, so I am not going to attempt to tell you just how it is done.

R. M. Hussey: I can not carry on the discussion, but I have a question or two that I would like to ask. In the kind of work we talk about in mentioning A. O. Smith, speed of producing the welded seam in inches per minutes is a very pertinent point when

you think about production, and in that very connection, what is the speed in inches per minute, or feet per minute, that we could depend on right now from the welding wires and the welding equipment that is on the market, and what speed are we likely to attain with new developments?

This is a question I would like to hear some sort of an answer on. Is it not generally conceded now that speed, or higher speeds in welding will be more a function of electrodes and come about by new developments in the electrodes rather than by developments in the welding machinery, or will higher speeds be attained through developments in both the welding rods and in the welding machinery, and what is likely to be the top speed that we can figure on for a while?

J. F. Lincoln: Welding speeds by the use of bare electrode or wash coated electrodes, are determined by the amount of current used and the size of the electrode. There are, however, on the market a number of covered electrods by the us of which very much higher speeds are possible, the reason for this being that with the heavy covering on the electrodes a very much higher voltage can be used in the arc and the coating also acts to mechanically keep the molten wire from spattering. These electrodes have certain other advantages such as producing a good deal more ductile weld because of the absence of iron oxide and a very much better looking surface for the same reason. They have the disadvantage of forming a very large crater so that a large pool of metal is molten during the welding period, thus making it impossible to weld except in a down position. There is very little doubt that these types of electrodes are going to be more and more used, and because of that fact higher and higher speeds are going to be obtained.

J. O. Keller: Mr. Lincoln prefaced his remarks by stating that what he said was true a week ago or two weeks ago. I think that is the way most of us feel; that we don't like to say anything now for fear that yesterday somebody did something different, and the progress is so rapid that we think that whatever we say is going to be hurled back at us as being behind time tomorrow.

I think other members of the audience would like to say something or contribute something to the discussion which has been very interesting so far. Don't hesitate to get up twice if you said something before.

L. R. Foust: I would like to ask if it has ever been found that a successful metallic or carbon arc butt welded joint can be made on elbow sections of a pipe of 30 inches or over in diameter, say on a 90° elbow, made up of four or five different plates. Can that be successfully welded by any process as a butt welded job?

J. F. Lincoln: I know of no reason why sections of this kind should not be made with entire success. There are any number of manufacturers who do make pipe of this kind with entire success.

L. R. Foust: In our experience we have found that so far it has been impossible to make a thoroughly reliable joint of this kind without annealing. In other words, it places the weld material in tension, whereas with the lap weld it is in shear. The only comments I have ever been able to find on it were in some Japanese practice on a large welded pipe job. On that job they eliminated butt welds on elbow sections.

J. F. Lincoln: I see no reason why there should be any unusual stresses in an elbow joint of this kind. It would seem to me it would be a good deal more difficult to make a straight butt joint in a piece of pipe than in an elbow joint where it is possible from the very shape of the piece to get any amount of contraction necessary. It would be theoretically better to make this a lap weld than a butt weld, but these have been made successfully in hundreds of cases both ways.

R. L. Foust: Have they ever been able to make the circumferential welds?

J. F. Lincoln: There are any number of circumferential welds being made in pipe in all parts of the country with entire success.

W. W. Barefoot: Which do you find the best—AC or DC welds?

J. F. Lincoln: We like the direct current very much better than alternating current for welding.

W. W. Barefoot. I mean current coming from transformers.

J. F. Lincoln: There is a good deal that can be said on both sides of this question. The reason we believe in and recommend direct current is because of the fact that with a direct current weld more heat is liberated at the positive side, which is the work, than on the negative side, which is the electrode. Because of that fact the rate of melting with a certain amount of current flowing will be less with DC than with AC, but the size of the crater into which this reduced number of drops must fall if a successful weld is to be made, is very much larger, thus eliminating a variable which generally is the chief handicap to successful welds. There is no doubt that successful welds have been made with the alternating-current—there is no doubt, however, that very much less skill is required to make an equally successful weld with direct current than with alternating current. Therefore, an operator using direct current will have a higher percentage of success than with alternating current.

K. L. Hansen: With reference to this question of polarity, the electrode is negative and the work is positive as indicated by Mr. Lincoln on the blackboard, but there are many applications where the polarity is reversed and where it is a decided advantage to be able to reverse the polarity. Now when I gave my talk this morning, I mentioned chrome nickel allows and non-ferrous materials, and hard facing alloys. They all use the electrode positive and the work negative. It seems to flow very much smoother and to lay down smoother, a smoother bead than the alternating current. In other words, where you have the choice and can reverse the polarity if you wish to do so, it is a distinct advantage that the alternating current does not have.

Incidentally, it is not only in alloy steel welding that reversed polarity is used. In welding heavy materials of mild steel, when covered or heavily coated welding rods are used, the polarity is often reversed. Also a bare rod whose surface is substantially free from lime will flow smoothly with the electrode positive. Because the heat concentration is on the positive electrode the rod will melt off faster with the same current when it is positive than with either so-called straight polarity or with alternating current.

Therefore, when it is desired to build up material at a high rate where penetration is of less consequence, reversed polarity sometimes works out very well. This is obviously an advantage which cannot be obtained with an alternating current machine.

J. F. Lincoln: I just want to add to that statement of Mr. Hansen's—there are, of course, some places where the size of the positive pool of molten metal is a handicap rather than a help. This would be true, of course, in the case of high manganese steel or high carbon steel rod where the presence of high heat will largely burn out the manganese or carbon. In cases of this kind the reversing of polarity is very much better than the use of the alternating current, and also, the operation of the arc will be very much easier.

Electric Galvanizing

By R. M. CHERRY*

The application of electric heat to galvanizing is relatively new. Probably the oldest installation of commercial size is not over three or four years old. To date there has been installed a total of approximately fifteen electrically heated galvanizing tanks having a total connected load of approximately 2500 kw.

These installations have covered a variety of work such as wire, castings, structural steel, etc.

The sizes of the tanks that have been installed using electric heat have varied from 20 in. to 43 in. in width and from 4ft. to 31 ft. in length.

There is now being installed in Reading, Pa., an electrically heated galvanizing tank having inside dimensions 43 in. wide, 25 ft. long and 48 in. deep. This equipment has a total connected load of 615 kw., divided into three circuits, each of which is independently controlled. This equipment has been designed for a maximum production of seven tons of steel per hour.

The desirability of electricity for galvanizing or for any heating application to which electric heat can be applied, is today unquestioned from every standpoint but that of cost. A superficial investigation of costs is often unfavorable to electric heat but a thorough study of the many factors entering into the heating cost of galvanizing may present the opposite picture.

If only the relative cost of B.t.u. between fuels and electricity is considered, we have not begun to make a cost analysis, but merely a few simple calculations. What any manufacturer is interested in is the total cost of the finished product shipped and not the B.t.u. cost.

The principal items that enter into the cost of galvanizing are

I. Cost of Heat Source
II. Zinc
III. Maintenance—Continuity of Service.
IV. Labor
V. Quality—Rejects and Re-runs

I. Cost of Heat Source:

Ratio of fuel and electric costs are average operating conditions at full load is as follows:

Fuel	No. B.t.u.	Cost per 100,000 B.t.u.	Ratio	Ratio 50% Combustion Efficiency
Oil at $.06 per gal...	140,000	$.043	1	1
Natural gas at $.50 per M. cu. ft.....	950	.053	1.23	1.23
Artificial gas at $.80/M. cu. ft.....	550	.146	3.4	3.4
Electricity at $.01 per kwh.	3,412	.293	6.8	3.4

Assuming an average combustion efficiency for fuels of 50% (the conversion of electricity to heat is always 100% efficient), the ratio of cost of useful B.t.u. is shown in the above table. If you add two cents per gallon to the oil for burning costs, the above ratio becomes 1 to .93 to 2.5 to 2.5.

For the conditions assumed this probably represents a true ratio of cost of heat source when operating continuously at full load.

As a rule a galvanizing tank is always kept hot. During idle periods such as over week-ends the temperature is usually dropped to about the melting point of zinc.

If the tank is operated on a 125-hour week production, it will be idle approximately 30% of the time. During idle period the only heat loss from the electric furnace is the loss by conduction through the walls and the cover. These losses can be made very low by the use of suitable insulation.

The fuel-fired furnace has, in addition to the wall and cover losses, the combustion or flue losses.

II. Zinc:

The zinc cost is represented by the zinc used in coating the work and the dross formed.

There is for every type of product an economical thickness of coating. The thickness depends largely on the temperature. A furnace that will at all times maintain a uniform and accurately controlled temperature will produce the desired economical coating. Electric heat more readily lends itself to such temperature control.

The dross formed is also governed by the temperature and again we see the necessity of the uniformity and accuracy of control as obtained with electric heat.

Assuming that 150 lbs. of zinc at 8 cents per lb. is used in coating one ton of steel, the cost of zinc would be $12 per ton of steel galvanized.

The power consumption for a fairly large tank

Industrial Heating and Welding Engineering Dept., General Electric Co., Schenectady, N. Y.

operated at full load will be approximately 100 to 120 per ton and at 1 cent per kwh. the power cost is $1 to $1.20 per ton of steel galvanized.

From the above figures we see that it will be necessary to save only 8 to 10% of the zinc to pay for the total power used. When comparing electricity with fuel oil or natural gas it would be necessary to save only 5 to 6% of the total zinc used in order to place the cost of heat source on exactly the same cost basis. Certainly a saving of 5 to 6% in zinc used is not an unreasonable expectation with the uniform and accurate temperature control obtained with electric heat.

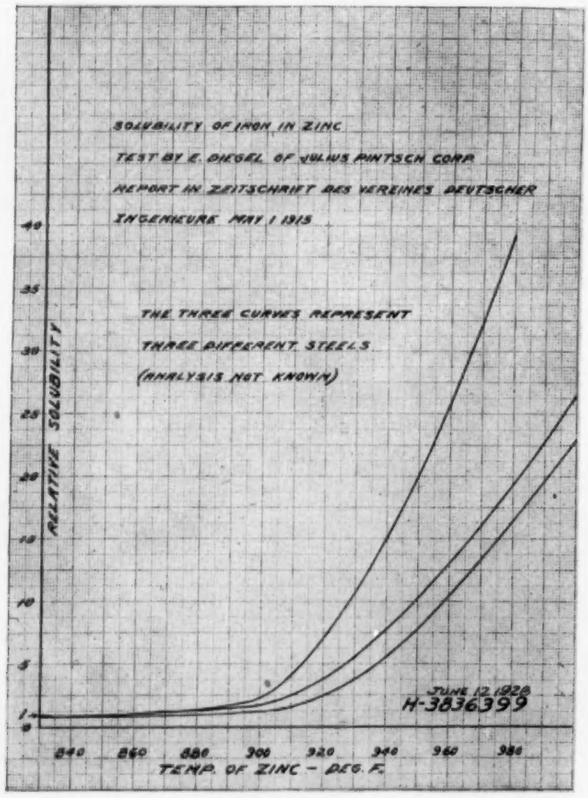

FIG. 1.

III. Maintenance—Continuity of Service:

The replacement of the tank represents the largest item of maintenance. The life of a tank is governed by the temperature, production, design of tank and design of furnace proper.

High dross and short tank life go hand in hand as both are largely dependent upon the temperature. The rate of solubility of iron in zinc is practically constant from the melting point of zinc up to about 860 deg. F. The rate of solubility increases gradually up to about 900 deg. F. when it begins to increase at a very rapid rate.

In the case of fuel fired tanks the heat source consists of one or more hot spots, and the circulation of the gases are depended upon to even out these hot spots. Naturally, when the heat source consists of such high temperature spots, there is the danger of local over-heating of the tank.

In the case of the electrically heated tanks, the temperature of the heat source (heating element) is relatively low—approximately 150 deg. F. above the chamber temperature. The heat is applied uniformly throughout the heating chamber, there being no hot spots. Usually the heating units are mounted on the side walls, the bottom of the units being kept above the dross line of the tank.

A tank failure represents not only the replacement of the tank and often considerable of the brickwork, but a loss of zinc and loss of production. These items may be equal in cost to a considerable proportion of the total cost of the heat source.

Certainly the tank which is uniformly heated and accurately controlled will give the longest life, and therefore the lowest maintenance. A tank does not always fail due to the action of the zinc on the iron but the expansion and contraction of the tank with heating and cooling causes severe strains, particularly where the tank is not uniformly heated. Many failures have occurred due largely to improper design of tank.

The design of the furnace proper affects the life of the tank. The dross that accumulates in the bottom of the tank is a fairly good heat insulator. Therefore, to attempt to force heat through the tank below the dross line will result in overheating this portion of the tank.

The electric heating units can be located and distributed as desired and they always remain so located, there being no change from day to day of the uniformity of heat distribution.

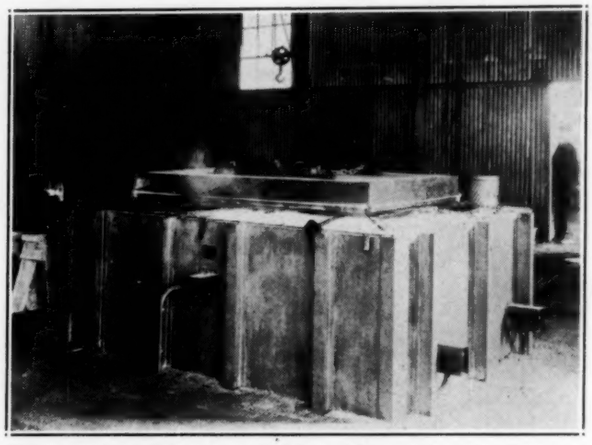

FIG. 2—70-K.W., 220-Volt Electrically Heated Tank, 5 Feet Long by 3 Feet Wide By 3 Feet Deep, for Galvanizing Transmission Line Parts. The Southern California Edison Co., Los Angeles, Cal.

The amount of work put through a tank will affect the life of the tank, particularly if it is fuel fired. As the production increases, the amount of heat required is increased and the temperature of the heating chamber must be raised to meet this condition. Forcing of a fuel fired tank will increase the hazard of local overheating.

There is a galvanizing plant that has been reported as having obtained a life of seven years on a coke fired tank and an average of about five years. No doubt, this is true but the whole story has not been told unless the size of tank, operating temperature and production have been given. The particular coke fired tank that gave a life of seven

years was used for light work, there being relatively few pounds put through the tank.

In this same plant there are other coke fired tanks used on very heavy production. The life of these tanks is less than a year.

IV. Labor:

With electric heat, the labor required for burner attendance or for firing in case of solid fuels is eliminated. The electrically heated tank does not require as close supervision during idle periods.

The working conditions in a galvanizing shop are not the best under the most favorable conditions. The elimination of the products of combustion from the room and the lowering of the room temperature as obtained with electric heat will greatly improve the working conditions.

Improved working conditions are of interest not only from the actual saving in labor but from the standpoint of its effect on the labor that must be employed. The greater comfort and safety of the employees assures better loyalty, co-operation and lower labor turnover.

FIG. 3—198-K. W., 220-Volt, 3-Phase, 60 Cycle, Electric Galvanizing Tank, Inside Dimensions 36 Inches Wide by 15 Feet Long by 36 Inches Deep. Used for Galvanizing Structural Steel and Cast Iron Parts in Plant of Delta Star Electric Company, Chicago, Ill.

V. Quality:

Quality of galvanizing (assuming proper zinc) depends largely upon the temperature, and the judgment of the operator. Where work is put through the tank continuously such as wire and sheets, on a definite time cycle, then the human element is eliminated after the conditions are once set.

Such work as pails, tubs, castings, structural steel shapes, etc., are handled either one at a time or in batches, and the quality of the work is left to the operator.

Certainly the electrically heated tank, with its automatically controlled temperature, will provide the operator with the best conditions for obtaining high quality.

Even a small percentage of rejects and re-runs will equal the total cost of heat source.

TEMPERATURE CONTROL

In each of the major items of galvanizing costs as discussed above, the temperature is the largest factor in such costs.

The electric circuit is controlled through an automatic control panel by a temperature control instrument which is actuated by a thermocouple placed in the zinc or in the heating chamber or both places.

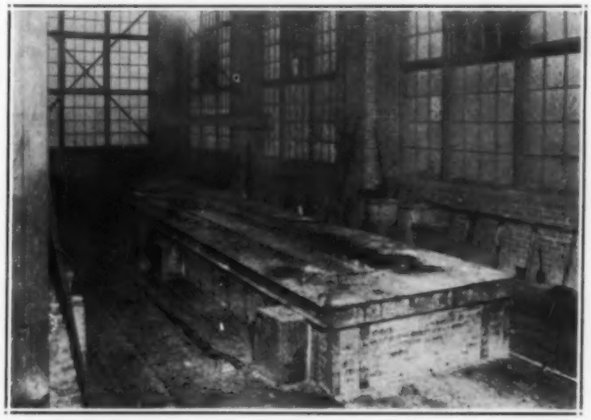

FIG. 4—Electric Galvanizing Tank. Inside Dimensions 22 Inches Wide by 30 Feet 6 Inches Long by 4 Feet Deep. 405-K. W., 220-Volt, 3-Phase. Used for Galvanizing Structural Steel Parts. Installed at Walter Bates Steel Corporation, Gary, Indiana.

SOME OPERATING DATA

The power consumption of three sizes of electrically heated tanks operating continuously is given in the following tables—temperature, 850 deg. F.:

Tank No. 1: Inside dimensions 30 in. wide, 36 in. deep, 6 ft. long, rated 90 kw., 220 volts, 3 phase, galvanizing miscellaneous steel parts.

Lbs. of Steel Galvanized per Hr.	Lbs. Galvanized per Kwh.	Kwh. per Ton Galvanized	Cost of Power per Ton at 1c per Kwh.
500	10.6	188	$1.88
1000	15.6	128	1.28
1500	18.5	108	1.08

Tank No. 2: Inside dimensions 36 in. wide, 36 in. deep, 15 ft. long, rated 200 kw., 220 volts, 3 phase, galvanizing structural steel parts.

2000	13.5	148	$1.48
3000	16.6	121	1.21
4000	18.5	108	1.08

Tank No. 3: Inside dimensions 22 in. wide, 48 in. deep, 30 ft. 6 in. long, rated 405 kw., 220 volts, 3 phase, galvanizing structural steel parts.

4000	15.3	130	$1.30
6000	18.4	109	1.09
8000	20.4	98	0.98

Electric Galvanizing

By R. M. CHERRY

Discussion

W. D. Livingston: I would like to ask Mr. Cherry how many men it takes to operate those different sized tanks. The first small tank would probably require one man. How does the ratio of operators increase as the size of the tank increases?

R. M. Cherry: I can't answer that question because the labor required varies with the type of work. A tank used for continuous galvanizing sheet wire, etc., would, of course, require very little labor. The labor required will depend upon the type of work and facilities for handling the work.

W. D. Livingston: That applies, of course, to gas or other forms of heat? I mean as compared with gas, would there be any saving in a 30-foot tank in labor over a gas tank?

R. M. Cherry: The number of men required would be the same for the electric as for the fuel fired, although the better working conditions and automatic control of the temperature would have an effect on the labor cost.

Wallace G. Imhoff: What Mr. Cherry said about electric heat is true. There is one thing, however, that I would like to say which is this: I do not believe that in the Pittsburgh district we can get a cent a kilowatt hour as an electricity cost. I believe that over in the eastern part of the state the electric current can be obtained at a cost as low as nine-tenths of one cent per kilowatt hour.

I want to mention some figures here which are of interest in comparing a gas-fired pot using natural gas in the Pittsburgh district, that is, in the Wheeling district, with an electric pot here in the Pittsburgh district.

The gas-fired pot held 38.7 tons of zinc. It took 42 hours and 15 minutes to melt all of the zinc in, and required 60,920 cubic feet of gas. Gas in that district is 45 cents per 1,000 cubic feet, which gives a cost of $27.41 for melting in the metal. That is at the rate of 71 cents per ton of zinc melted.

About a year and a half ago a full size electric pot on a commercial scale was installed which held 21.1 tons. It required 28 hours to melt in the metal and took 2, 941 kilowatt hours. In the Pittsburgh district—as far as I know now—perhaps, Mr. Cherry can correct me, but as far as I know—our cost of power here can only be obtained for a cent and a half a kilowatt hour. That would give a cost then of melting in of $44.10, and for the cost per ton would give a cost of $2.09 per ton as against 71 cents per ton using gas as a fuel.

I do not want to be misunderstood; I did not come here to criticize the paper, but to merely lay the facts, at least as I find them, before you. When it comes to first cost of these two installations, the cost of the electric pot was $5,000 for a 21-ton pot. The cost of the gas-fired galvanizing pot was $4,000 for a 40-ton pot, almost twice as large.

The operating and maintenance of galvanizing pots depends largely on the kind of material that is being galvanized. Anyone who is thoroughly familiar with the galvanizing industry knows that it is just as Mr. Cherry has said: "It is practically impossible to compare costs and that is the reason why I gave you costs merely on melting in the metal, not on production at all, because in production there are three important facts that influence costs. For instance, there are the materials and the equipment that are used in the plant. There is the method of handling and there is the labor, and the technique. The same old three things: Men, materials and equipment, and each one of these three things has a certain degree of efficiency in each plant.

There was one statement made that I do have some figures on for gas fuel which are interesting. This is in regard to flue losses, which Mr. Cherry mentioned as being inefficient in gas furnaces. It is of interest to note the actual figures which are given and were made by an engiener on a gas-fired pot in the Pittsburgh district.

The gentleman who made this test has stated that the stack temperature and flue gas samples were taken at the base of the stack. The flue gas indicates almost perfect combustion, and it is considerably better than the best figures obtained in August. The theoretical chart of flue gas temperatures shows 1000° Fahrenheit of a stack temperature will give a maximum CO_2 of 10.8; while on this practical installation the stack temperature was 1067° Fahrenheit with a CO_2 value of 11.7 per cent, which, of course, is very close to the theoretical efficiency.

Another furnace is operating with a gas cost of 60 cents per thousand, city gas, 850 b. t. u.; and that gas-fired furnace is now doing galvanizing using 850 cubic feet of gas per ton of metal galvanized. The dross production is 13 per cent.

In handling the electric pot there are distinct advantages also, and the main thing in the two fields is the difference in the cost of the power. One of the most important advantages of using electricity is the uniform heat distribution. That is a most important factor in galvanizing. Another important factor is the heat control. While operating, the supply of heat must be drawn either from intensity or from capacity.

I know of only one galvanizing furnace that has what might be called heat capacity, or supply. All of the rest of them draw on heat intensity. Electricity has the advantage, naturally, of distributing the heat uniformly over the side of the pot and avoiding any small localized concentration of heat, and, as Mr. Cherry showed by the curve, as soon as you go above 900° in any particular spot, from then on the corrosion and destruction of the pot is entirely a factor of the thickness of the side of the pot.

You will be interested to know of an actual installation of a pot that was 16 feet long. They started

out with an inch and an eighth fire-box, steel side. It was a coke-fired pot. The pot failed, and somebody had the idea that if they had only made the side a little thicker, it would have lasted longer; so they increased the thickness up to an inch and a quarter. Finally it went to an inch and a half. When I arrived they were using a two-inch fire-box steel side, and the pot went out in three months. They naturally wanted to know why it was that they had a longer life with an inch and an eighth thickness than they had with a two-inch steel fire-box side, and the only answer that could be given was the fact that the heavier the thickness of side, the harder it is to drive the heat through it, and in the old coke-fired kettles, which are heated by very small doors, as they increased the thickness of the side and kept driving the heat through those small openings, naturally the intensity of the heat became more and more severe and gradualy, of course, the pot failed.

R. M. Cherry: Since there are representatives of the local power companies here, I will ask one of them to answer the question in regard to power rates in Pittsburgh.

Mr. Imhoff referred to cost of an electric installation as compared with gas-fired installation. The comparison made was between one tank about twice the size of the other. The cost of an installation does not increase in proportion to size of the equipment.

Mr. Imhoff's figures of $0.71 for natural gas and $2.09 for electricity for melting down are interesting. Using one cent per K.W.H., the electric cost would be $1.40 a ton for melting down as compared with $0.71 for natural gas or a ratio of 2 to 1. This shows that my ratio of 2.5 to 1 was very conservative.

Comparing costs of galvanizing is rather difficult. To make an accurate comparison, it would be necessary to have two tanks, one electrically heated and one gas-fired doing exactly the same type of work and under the same conditions.

I would like to again point out that there is the possibility in almost any galvanizing operation of saving the entire power cost or the difference between the cost of electric heat and fuel, in the saving of zinc alone. If we recognize the fact that electric heat will give uniform heat distribution and accurate temperature control, then it is not unreasonable to exxpect a saving of 5 or 6% in the total zinc used. I think it is something that is well worth investigating.

R. W. Heller: I must correct the impression Mr. Imhoff has regarding power rates in Pittsburgh because I counted no less than twenty customers a minute ago where net rates of from seven to nine mills are being earned. Investigation would show, I am sure, many more customers with net rates less than cent.

It may be true that the rate of two years ago which Mr. Imhoff has based his cost per ton, were in the vicinity of one and one-half cents, but it is interesting to know that at this same plant the average net rate is lower than this figure and can be brought below a cent by correcting power factor.

Power rates are not high in Pittsburgh. We must banish the old idea of high rates so development and use of electric heat in industry can become greater.

F. W. Cramer: I am mighty glad Mr. Heller got up and spoke. I know in our Youngstown district we get 8 mills quite often, and in some of our power arguments I have used the Duquesne schedule and said that you could go still lower than that, but those were my figures.

Does any one else have anything to offer?

S. Grand Girard: About the thickness of the fire-box, if you actually use a fire-box of less thickness than the cast-tank that would be a saving in power due to forcing the heat through.

R. M. Cherry: There is no doubt that it would be possible to use a thinner wall tank and obtain the same life as obtained with a heavier tank fuel fired; yet there has been no investigation made.

E. C. Drake: I have very little to say, but I think that the comparison that was drawn on melting down is rather unjust to the electric pot. In other words, you are showing gas at its best and electricity at normal operation, because you have a greater temperature differential, heat source to work, on melting down than you have on production operation, thus favoring the gas or oil-fired pot. Furthermore, the melting down only occurs with the electric pot, we hope, about once in three years if it is held in continuous operation, whereas the melting down on gas or coke-fired pots might occur more frequently.

Wallace G. Imhoff: Since the subject of production has been brought up, I would like to give some actual figures on production of gas and electricity that I am familiar with.

A gas-fired pot, averaging about 1,000 tons a month in production, is costing about 40 cents a ton.

Some actual production figures that I have on the electric pot are $2.03 per ton, $2.01, $1.84, $2.53, $2.84, $2.67, $3.04, $2.84 and $2.87.

Other operating costs which I have on the electric pot are—operating nine hours per day $13.90, and an idle cost of $10.80, making a total operating cost of $24.70 per day. The average cost for nine hours for nine tons is $2.74 a ton.

Wirt Scott: What was that idle period?

Wallace Imhoff: Fifteen-hour idle period, $10.80. That is based on a rate of 1.5 a kilowatt hour. The power companies here possibly will give a more favorable rate. They didn't at least in this installation that I have the figures on. Figures on an oil-fired pot where tests were made and sheets were galvanized show five gallons of oil per ton of sheets, which means a cost of about 37 cents. If you figure on 7 cents for the oil delieverd at the burner, that is a cost of about 35 to 37 cents a ton for those sheets. These are actual figures, and I will be glad to give the name of the companies and you may check them up.

R. M. Cherry: I would like to ask Mr. Imhoff what the gas was for comparing with the $2 and $3.

Wallace Imhoff: The gas cost is 45 cents per thousand cubic feet.

R. M. Cherry: Per ton?

Wallace Imhoff: That would be 40 cents a ton.

R. M. Cherry: I would like to ask Mr. Imhoff what was the size of the electric tank, the size of the gas-fired tank and production per hour of each.

Wallace Imhoff: The gas-fired furnace was 14 feet by 3½ x 4½, or about a 40-ton pot, and the electric pot was 10'10" x 40" x 49" and held 21 ton.

R. M. Cherry: What did you say was the production per hour?

Wallace Imhoff: The production on the gas-fired pot was about 35 tons per day, and the production on the electric pot was a ton an hour, or 9 tons per day.

R. M. Cherry: That is the difference as you have an electric tank 11 ft. x 4 ft. x 4 ft. compared with a gas-fired tank 14 ft. x 4 ft. x 4 ft., the electric tank practically as large as the gas-fired tank yet operating with only one-fourth the production. The heat losses are the same whether the tank is idle or running full production and naturally the greater the production, the lower will be the power consumption per ton. If the 11 ft. x 4 ft. x 4 ft. tank was operated, at the same production as the gas-fired tank, then the power cost at one cent per K.W.H. would be approximately $1 to $1.20 per ton.

Wallace Imhoff: I thoroughly agree with you that with gas or electricity, or oil, or anything else, the cost varies according to production and that is why I chose at the very beginning to compare them where there wasn't any production, because the production depends on the kind of material; it depends on the labor; on the organization and on so many other factors that I chose not to enter into that at all and therefore I still go back to my original comparison which I think is better.

Walker Anderson: Mr. Imhoff stated that costs varied so much with different production rates that he did not make his comparisons on this basis. However, I am wondering why he chose the period of initial melt down. Why not, just as reasonably, make comparisons on the basis of standby losses. This would certainly be more favorable to the electric pot, but just as valid a comparison as the one used by Mr. Imhoff.

Actually, it seems to me that Mr. Imhoff and Mr. Cherry are in unusual agreement. Comparative economies—electric power vs. fuel cost—as cited by Mr. Imhoff, merely verify those given by Mr. Cherry, so that discussion here has lost considerable of its importance. The only answer to the question will be operation of an electric and a fuel-fired pot under practically identical conditions. This is just the data we now lack, but I am hopeful that it will be available in the next twelve months.

Wallace Imhoff: You can figure that out. I have the actual figures here on how much it takes to hold the electric furnace idle, and on how much it takes to hold the gas furnace idle; so that it is easy enough to figure it out.

Walker Anderson: That gives a good comparison for that particular condition.

R. W. Heller: I just want to add that the rate I mentioned is not a special rate for galvanizing or anything else. It is a standard power rate for general service above 5 K.V.A.

Wallace Imhoff: One and one-half is what they were:

R. W. Heller: I know that Mr. Imhoff was at one time quite favorable to electric galvanizing and expressed the opinion that electric heat would play an important part in future galvanizing. It is, therefore, somewhat disappointing to hear him express other opinions today. I believe that he did considerable experimental work at Mellon Institute and I would like to know how the results of this work compare with results obtained in commercial practice and, if the cost per ton in commercial practice was excessive, why it was not detected while the experimental work was in progress.

Wallace Imhoff: I don't quite get what you mean in regard to this. Do you mean the small, experimental installation?

R. M. Heller: Yes.

Wallace Imhoff: There you couldn't get any figures that would mean anything on an experimental basis as far as production and costs are concerned.

I agree with Mr. Heller that the pot on which I was giving the figures was put in two years ago. Now I grant him that today the newer rates may be very much less, but even considering this, and I am not interested in either one or the other; I am interested merely in facts, and as far as I can see in actually dealing with facts and then commercializing them, I feel this way: That gas, if it is properly handled, will be cheaper than the electric heat. There isn't anything, as far as electricity is concerned, that you can't get with gas. You can get the same heat distribution; in fact instead of burning gas the way it is generally done in the industry— by shooting the flames in against the side of the pot—the newer type of furnace does not do this. Instead of burning gas by impact, it is burned by combustion in suspension.

If you talk ignition point to the average man who has a gas-fired galvanizing pot, he hasn't the faintest conception of what you mean. He knows that the mixture in his automobile when he starts out in the morning must be richer, because the engine is cold, and he knows that after it gets heated up the fuel can be cut down, but ask the ordinary man who has a gas-fired pot about his ignition point in his galvanizing plant. He will tell you that he doesn't know anything about it.

As far as radiation losses are concerned, I have actualy shown, and I have the curve here to show that 60% of all of the heat that is put into a galvanizing furnace is lost by radiation from the top furnace, and, gentlemen, any of you are welcome to come up here and look at that curve. You can insulate a gas-fired pot. It is being done. In other words if you take the gas burners out, we will grant, everything being the same, and put the electric heat in, and use exactly the same construction, then you will go back to the cost of the electric power, and I think you will find that it will be more than with the gas-fired furnace.

The Electric Annealing Furnace

By JAMES KNIVETON*

A few years ago the presentation of a paper upon the electric annealing furnace would have been considered largely introductory in its character. That is, the presentation of research data rather than as it is today, a presentation of accomplishments in a definitely established industrial heating operation.

Without going into the broad scope of the history of the development of the electric furnace, it is interesting to point to the fact that history, as it pertains to the electric annealing furnace, is really a little over ten years old, because it was only between 1918 and 1919 that there were sufficient facts and data upon what had been accomplished in experimental furnaces during the war, to determine whether or not the basic principles could be applied to standard industrial operations therein, meeting competition in regard to quality and cost of operation.

We now hear lectures on this subject wherein we might assume from the attitude of the speaker that electric furnace history runs back in decades. True, we did have electric furnaces twenty-five years ago but they were of small, experimental type relegatd largely to the laboartory or small tool room work. Therefore, in realtion to the subject upon which this paper treats, namely the production furnace, we must consider that we have only approximately ten years to look back upon, and really after that to marvel at the growth of its application to industry during the intervening period.

The field of application of the electric furnace at first was largely within what might be termed the luxury products. By this we mean those items which can stand for higher cost of production than ordinary items. Then came the treatment of those items which had to meet special stresses, particularly in the automotive industry, such as forged parts. Since that time the field has grown broadly in practically every direction, and with the reduction of power rates, making possible competitive consideration in cost of production, the electric furnace has come to be considered in every furnace negotiation.

What might be termed as the slogan of the electric furnace in the early days was "Ideal Heating Conditions." By ideal was meant that there were no gases being injected into the furnace which might cause detrimental surface conditions on the material being treated. But, since those early days we have come to realize that the chief and prime advantage of the electric furnace is absolute controlability, with a possible means of injecting into the furnace or treating chamber, those gases which can be used to advantage in the protection of the surface of the treated material.

Prominent metallurgists have given detailed facts in that there are certain advantages in what we might call slight oxidation—so that one of the original thoughts, the absolute lack of oxidation, has passed into discard. In fact, we know now that it has never been possible to secure an absolutely unoxidized surface in an electric furnace without the injection of protecting gases.

The controllable feature just mentioned is one which is advantageous especially in those operations called bright annealing, and in the treatment of finished objects, and of course in the cases where even the slight variance in temperature control and uniformity means detrimental results in the grain structure. I believe that this will become more apparent as the new alloy steels come into greater use.

With reference to the types of annealing furnaces adaptable to electric heat, if we are to consider them purely from the standpoint of the installation of resistors it can be considered that every type of furnace is adaptable. We say this because while originally we were dependent upon the metallic resistor to give us the temperature of operation, thereby limiting operation to approximately 1700° F., we now have numerous types of special resistors such as the pure graphite, Carborundum and those new special alloys which are capable of carrying the temperature up to 2800° F. the outside working limits in heat-treating applications.

There is, however, a very definite classification pertaining to what type of furnace is adaptable to electric heat and what is not. By this we mean that there are types of furnaces especially adaptable to electric heating. For instance, the small box type and continuous furnaces, wherein because the clearances are limited the efficiency of an oil or gas furnace is consequently low; resulting in a higher cost of operation and with results not as good as can be obtained with electric heat.

In giving consideration to large car hearth and continuous types of electric furnaces, we must consider entirely different factors, for the high efficiency of an oil or gas furnace necessitates that the electric unit must work with a very low power rate. Or, there must be a special desire for a surface condition and accuracy of anneal that can only be obtained in an electric furnace. Of course, the latter is a questionable point, because today with the modern types of automatic combustion and temperature control systems, the same character of temperature control can be equalled as that obtainable in the electric furnace.

It is the writer's personal opinion that the electric annealing furnace has a very distinct position and one which will grow steadily, but which is liable to be retarded through the over-zealous work on the part of specialists who can only see every heating operation from the electric heating standpoint. We see the same sort of individual in the oil and gas field, and in each case instead of acting as an advancement agent to the industry he aims to promote, he really acts as a deterring factor, because in his over-enthusiastic advocation, furnaces are misapplied. Evidence of that fact is on every side, and that misapplied furnace stands out like a sore thumb on the entire industry and probably kills ten other installations which should have been electrically heated.

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I would like to mention one of the dangerous features which has grown up in this industrial furnace field, namely the establishment of trade organizations. Some are disguised under the nome-de-plume of a research and development organization, but fundamentally they are organizations established and supported by the industry producing the means of heat development. This refers to electric power, gas and oil. Now, naturally these organizations are out to sell their specific product and in the majority they are organized by men who are entirely too busy with their own interests to give more than a glossary sort of interest to their committee. What they do give is money, and this money purchases the services of a secretary and numerous working assistants who are allowed to go to the farthest extreme in the development of figures and data to show that particular kind of heat is the only one which should be considered.

For instance, a few weeks ago in discussing the possible future of electric heat in industry with a prominent individual connected with the power industry, I was given some very elaborate and convincing figures on the advancement of the electric furnace in industrial effort. A short time later I talked to a very important individual connected with the gas industry and he showed me on his side, even more astounding figures indicating how the gas industry had advanced eight times as fast as the electric industry. The electric furnace was falling a little behind, based on his figures.

You can see that while such figures are important from the standpoint of the production manager to the industry to which they refer, they are not important to you, the users of electric furnaces, and they are only misleading in the story they tell, because whether the electric furnace had advanced 5% or gone back 5% has nothing whatsoever to do with the question of whether or not it should be applied to a certain heating operation.

In our opinion, industry should forget for the time being what the operating cost of electric annealing is, and concentrate its effort upon what metallurgical results can be secured. If those results are sufficiently important and superior to anything obtainable elsewhere, then the solution of the electric furnace problem as applied to industry is at hand. History has proven when anything is necessary to industry, its cost and its means of application became quickly solved.

The efficiency of a heating medium or a heating furnace, of course, is an important item. But, again, the question arises whether or not high efficiency should be the goal rather than the most superior results. If both can be tied together, that is high efficiency and superior results, you have an ideal condition. But, from a sales propaganda standpoint, we often see furnace engineers strive to the utmost to secure record results so that on a test run it can be shown that ½ to 1 lb. more work has been produced per unit of heat than has been produced in any other furnace yet built. While that increase of production is important, if it has been necessary to sacrifice flexibility, ease of handling, etc., it fades into insignificance.

Without doubt, the design of a furnace is a definite factor in its efficiency of operation both as it pertains to production and power consumption, but it is not as important as some claim, for the modern furnace engineer is quite a competent individual and must be considered as scientifically trained as any other individual in the engineering fraternity. He cannot guess any more; he accumulates definite facts either from his own experience or from that which has been established by others and by the Government research divisions, and these he ties in with his designing ability. This is why you find so many furnaces of different grades of manufacture which follow such close lines.

Recently at a meeting of a technical society in Philadelphia the opinion was expressed by one individual in attendance that he felt the reason furnaces were sold was largely on the effort or the "bunk" of the salesman. That is why in one district you find a great many oil furnaces, in another an overwhelming number of gas furnaces and in another a majority of electric furnaces. Well, that is stretching the point a little too far. Nothing would be sold if enthusiasm and punch were not behind it, but for an industry such as the electric furnace industry to have grown to the extent it has within ten years indicates that there must have been something more than bunk behind it.

The furnace engineer realizes that the public is becoming more and more accurate in passing judgment on his product. Therefore he must adopt the most modern methods in design and construction. This means that the entire furnace industry, rather than broadening out away from itself, will gradually concentrate into definite principles and definite lines just as the automotive, the steel, the radio and innumerable other industries have done. So that while design does have a definite effect upon efficiency, you can take it for granted that the majority of furnace engineers are going to recommend an equipment that will have the maximum possible efficiency.

The electric annealing furnace is especially adaptable to continuous operations where so many pounds of work per hour are to be produced and the product is of like character. In fact, with a continuous electric furnace results can be obtained which are not possible with any other type of heating. For instance, we have just received data on a small continuous electric annealing furnace, 5 ft. long and 3 ft. wide. This furnace is producing more work than one now in operation with a hearth area of 14 ft. in diameter fired with oil.

This efficiency of the electric furnace is particularly noticeable with reference to the treatment of small objects. Note we refer to continuous production of so many pounds per hour. This is because the electric furnace is not flexible and that is one of its disadvantages against the oil and gas furnace. In a fuel fired furnace you can operate with a 25 or 30% over or under load without impairing any part of the furnace or affecting its over-all efficiency, but you cannot do so with the electric furnace. An electric furnace cannot be operated with an overload without burning out the heaters. If it is on an underload the cost of operation goes up because of standby and special load charges.

The temperature ranges of an electric furnace are dependent upon the type of heater or resistor used. Metallic resistors of first quality Nichrome are good for operations up to 1800° F. but even at that temperature unless the heaters are protected, life be-

comes shortened, because at 1800° the heaters themselves due to temperature gradient, are probably working at 2000° at which temperature the metal becomes soft. The best operating temperature for the ordinary metallic resistor is 1650 to 1700° maximum. At this temperature we know of many instances of eight or nine years of life without any necessary replacements. At temperature above this point, there are possibilities in the future of a metallic, for from Germany, especially, new metals are coming which seem to have rare possibilities. In our laboratory we have some metal which has been tested up to 2500° F. but at present it is purely an experiment for its cost is excessive and electrical conditions are not ideal.

Above this range there are the pure graphite, carbon and carborundum resistors. Of these probably the most adaptable is the carborundum resistor, because of its greater life and its possibilities of reduction to scientific principles of application. Therefore, with the range of the electric furnace as it stands today we can consider we can go from room atmosphere to 2600 or 2700 degrees on a perfectly commercial basis.

As stated, there are numerous types of heaters or resistors. We use these two terms because often we find individuals understanding one and not the other. As to the specific form of the heater or resistor which is best, that is where all the cooks don't agree.

It is not my intention to present in this paper what I believe is the most correct type of heater because I think the general public is gradually coming to realize that they all have good points. The simple principle upon which you can gauge whether or not a resistor is correct or incorrect is in the fact that the electric furnace obtains its heat through radiation. Therefore, the resistor which offers the greatest possibility of radiation is the most scientifically correct resistor. Consider that all sides of a resistor are radiating heat. Now if a large proportion is opposed to the wall of the furnace chamber which does not carry off heat, then the heat must first be radiated from the resistor to the wall and then back again to some other location. In doing so it really bucks against itself, causing the temperature to rise at the heater location—the cause of hot spots and burn-outs so that by the largest amount of radiation we mean free radiation. To determine this all you have to do when you have furnace propositions submitted to you is to take out your pencil and drawing board and place on it in design the resistors that are recommended. Then draw direct radiating lines out from it in every direction and see the one which has the greatest possibility of radiation direct to the work, and the least possible radiation against itself, the result you can take it as fundamental that you then have the best resistor.

Refractories, of course, play a large part in the efficiency of a furnace, and in this field just as we have in the resistor field, we have many unusual recommendations but the important point is in the fact that what you want to do in an electric furnace is to keep the heat in. Insulating materials keep it in to a greater extent than ordinary refractories such as fire brick. There is a limit, however, to where you can go with insulation both from good furnace practice and from the saving in lost heat by radiation. These limits are well known and established. Just because someone recommends 4½" more than is necessary is no indication that you are going to pay interest charges on the investment.

Some furnace builders recommend an inner refractory or fire brick wall. Some of them do so because of the type of heater necessitating a firmer support than the insulating material would give, and some because they claim that the heat stored up is an advantage against quick reactions in the temperature of the furnace.

An important point to be considered is the question of guarantee in an electric annealing furnace, and what constitutes a guarantee. We see one concern guaranteeing so many pounds per K.W.H. notwithstanding that they know the operation cannot be carried out on the test heat and probably never will be carried out. We installed a large electric annealing furnace a number of years ago where the negotiation involved nearly thirty days of discussion as to just what we would and would not guarantee. For six months after the completion of the installation we tried to have a test run to determine the results. Finally, this concern stated they did not want to know the results because the work was so satisfactory.

I feel that the system of guarantees which has been built up through sales effort is detrimental to your interest in the electric furnace. What you really should do is to consider the subject from the broad plan that the steel casting industry had to consider the electric melting furnace, i. e., the manufacture of a better product, and then gear up your Sales Division so as to sell that better product. It is not so many years ago that we could purchase steel castings in Chester for 6 cents or 7 cents per pound. Today we do not hesitate to pay 18 cents to 25 cents per pound for electric steel castings. A few days ago our Purchasing Division received a quotation from one concern offering open hearth castings at approximately 35% cheaper than those of electric steel. Does this not clearly indicate how you should consider the electric furnace? It has been "the trying to bring it within the field of the cheaper fuels," which has retarded its application into many of your operations. Quite frankly, it is my opinion that if you have to consider the electric furnace from a purely competitive cost standpoint in relation to oil or gas, in the majority of cases the electric furnace is simply going to be out of luck.

Of course there are cases where low power costs and high fuel costs reverse the conditions. That is always possible, but in 90% of the cases the correct procedure is to understand the fact that you are going to produce a superior product, thereby allowing the expenditure of a greater cost of production, but in the end, expect to reap a greater return.

Possibly through the heading of this paper you have expected me to discuss the question of furnace designs, cost of production and cost of upkeep. But, quite frankly this is such a broad subject today that I would be in just the same position as if you asked me to discuss the oil fired annealing furnace. As you know, such a problem wouldn't be cleared up in two or three days. You would have to split it into many elements, for instance—the car hearth furnace —that would be sufficient to cover one day's dis-

cussion. So would be the case in the electric annealing furnace. For this reason I have presented, rather than details which could only be glided over, some suggestions that industry can well follow in its consideration of the electric annealing furnace. It is, without doubt, here; it will increase in its application, and it has a definite place in industry. While it may not possibly be applicable to your work at the moment, it may be tomorrow or next year, and it would pay you to give consideration along the thoughts I have outlined.

In closing, if there are any particular points in which you are interested, I would appreciate your presenting the question which I will answer to the best of my ability. If it involves a question which is too broad for the limited time allowed for this paper, I would appreciate your giving me your name and address, and our Research Division will be very glad to submit to you, all of the available data on that particular subject.

As stated, I have purposely made this paper general for the reason that it is a very hard problem to present such a paper and touch upon all of the vital points. They can more properly be brought up in open discussion, where a more direct and pertinent answer can be given.

The Electric Annealing Furnace

By JAMES KNIVETON

Discussion

J. O. Keller: I want to thank Mr. Kniveton for that very fine paper. I think it was given with a sane, fundamental viewpoint, free from prejudice and it was expressed in very beautiful English, something you don't always have in a paper from an engineer, as Mr. Hansen said. I feel that I am in the class Mr. Hansen referred to but I know a good address when I hear it, and I want to thank Mr. Kniveton.

The subject is open for discussion and questions. Perhaps there will be some questions that may make him get down to details his paper didn't cover. Does anybody have any questions? I am sure you have annealing problems, considerations for installation of annealing furnaces, and the like. Has anybody anything to offer further in the way of discussion if you haven't any questions?

Wirt Scott: I would like to ask if any one here knows anything about decarbonizing, what causes it or how to prevent it?

James Kniveton: I believe decarburization is caused by the presence of oxygen within the furnace chamber. This condition I know exists in an electric furnace.

Wirt Scott: I don't believe it is oxygen that causes it. I think that is quite an important subject, and if anybody has any information to throw any light on it, I would like to hear from them. Tests that I know about that have been made of decarbonizing, show that it is something other than oxygen eliminated in the furnace.

J. O. Keller: Can anybody answer that question for Mr. Scott, or give him their theory on it?

Wirt Scott: It is quite an important proposition in annealing. I know one particular plant annealing rod steel, that is, steel for drill rods, for roller bearing stock, and stock of that kind, the product being annealled in an oil furnace after the first hot drawing. They got a certain amount of decarbonizing, also a certain amount of scale from the first anneal after the cold drawing. For the finished annealing, they put the wire in big vessels and packed iron fileings around it so as to exclude the air entirely, so as to have a finished product that would not be decarbonized on the surface.

They installed two electric furnaces, pit type furnaces, with the idea of reducing the amount of scale on the wire, also with the idea of reducing decarbonization if possible, although no statements were made along that line at all, as to whether or not it were possible.

They started experimenting with the electric furnaces, and they found that the decarbonizing was less in an electric furnace than in the fuel furnaces. They found that the scale was just about one-half. Their test showed that decarbonization took place on the cooling cycle. In other words, the material had to be heated to say 1500 degree, and if taken out when that temperature was attained, it showed no decarbonization at all, but the longer it remained in the furnace, the more carbon was removed at the surface. So this particular company tried non-reducing atmospheres, by injecting artificial gas into the furnace, excluded all of the air before starting the heat process, they also tried other gases that were commercially available. I do not know if they tried any neutral gas such as nitrogen, which would have been very difficult to obtain, but they tried the usual run of gases without success. They tried burning charcoal and wood in the furnace to exclude the air. The results were somewhat better in the electric furnace than in the oil furnace, with a certain definite cycle for cooling. They found that if they hastened the cooling of this stock, the decarbonization became less, and they hit upon a cycle of removing the insulated cover from the furnace after the material was thoroughly soaked, and placing on top of the furnace, a sort of a sheet-iron cover with a hole in the center, and a sort of an angular ring around the edge so that the air would come down from the outer surface and down through the walls of the furnace, and up through the center, with sort of a chimney effect, reducing the time of cooling. The only way they could reduce the decarbonization was to accelerate the rate of cooling.

The results seemed to indicate that the scale

on the wire had some effect upon it, withdrawing of the carbon from the surface of the material. As I said, washing the oxygen out of the furnace had no effect on decarbonization of the material, and I was just wondering if any one here had any light to throw on the subject.

R. B. Saylor: We had some little experience along that line in the manufacturing of sheet steel. When sheets are rolled, there is produced on the surface a layer of iron oxide scale. When these sheets are box annealed in a reducing atmosphere for any length of time there appears a decarbonization which takes place near the edges of the sheet gauge. When the annealing time is prolonged the decarbonization seems to increase, so that it has been our idea that it is the scale, which is an oxide, that is partially responsible at least for decarbonization in the steel.

R. M. Cherry: I would like to supplement what Mr. Kniveton said about the maximum safe operating temperatures for electric furnaces. Mr. Kniveton stated that 1700 to 1750 degrees F. was about the maximum safe operating temperatures. A temperature of 1850 degrees F. is usually considered as the maximum operating temperature of an electric furnace. In any furnace the design of the resistor and method of supporting and spacing of the resistor governs to a large extent the maximum safe operating temperature.

The use of controlled atmosphere such as hydrogen, mixtures of hydrogen and nitrogen, etc., permits the use of the electric metallic resistor furnace at temperatures as high as 2100 degrees F. For instance in copper brazing with hydrogen atmosphere an operating temperature of about 2100 degrees F. is used and the life of the resistors is very satisfactory.

The use of controlled atmospheres for annealing will, no doubt, increase very rapidly. There is now being done a great amount of work on the use of controlled atmosphere.

Chas. E. Russell: My observation at the American Society for Steel Treating's past convention at Cleveland, is that the metallurgists expressed their opinions a great many times that the greatest advancement they can look toward at the present time is that when controlled atmosphere in furnaces is obtained it will give them the desired quality. I think, however, that the problem has been determining the amount and the kind of atmosphere that is given off from steel during any particular heating operation. When they discover what that is and how that mixes with the gases they put in the furnace, I think they will solve their problem, and that we will use furnaces with a definitely controlled atmosphere, giving definite, desired results.

R. W. Heller: I understood Mr. Kniveton to mention overloading the electric furnace, and I imagine by that he means the charge that is put in invites burn-outs. The statement is not quite clear to me, and I would like to have a little more information on it.

James Kniveton: What I meant was that if a furnace is designed, say to produce 1000 pounds per hour and an attempt is made to increase the production and get 1200 or 1500 pounds per hour, there is possibility of the heaters burning out in time unless properly protected. The load capacity of a furnace determines the connected K.W. imput and when it is originally installed the point should be stressed that it is designed to do a particular iob. Furnaces should be designed for the particular job it is to do unless it is miscellaneous heat treating which can be often handled with a standard line of furnaces.

R. W. Heller: In other words, the charging of 1500 pounds and the use of an hour and a half for the annealing cycle would not be harmful to the resistor element?

James Kniveton: You can increase the load providing you increase the time cycle.

R. W. Heller: What about the use of tap transformers, Mr. Kniveton, for a small charge? In other words, in the case of a furnace designed to anneal at the rate of one ton per hour, is the saving made by using tap transformers sufficient to warrant that additional expense in transformer equipment, for production of 1500 pounds or 1000 pounds per hour?

James Kniveton: We have never used the tap transformer. What we have done to take care of varying loads or smaller loads than what a furnace is designed for is to use the program control. If a furnace is designed for, say a ton, and the load should be a half-ton, with a program control you will obtain the same rate of heating in the charge that you would with a load of one ton.

R. W. Heller: Did you say program control?

James Kniveton: Program control will give a definite rate of heating. In other words, if you want to increase the furnace temperature with a charge, say from 25° to 50° per hour, the control will automatically take care of it. With program control the charge in a furnace will come to temperature at the same rate per hour regardless of the weight of the charge.

The program consists of a cylinder mounted to operate with the pyrometer mechanism so that the control point is constantly changed at a predetermined rate until the maximum control point is reached.

Chas. E. Russell: I think that Mr. Kniveton during his speech brought out one point which I don't think has ever been brought out to its fullest extent. He said that it might be a good idea to buy the equipment and then gear the sales department up to sell the better product. That is one thing that I think a great many of the manufacturers who have purchased and used electric furnaces have failed to do.

I know in our own territory we have made a great many attempts to get the manufacturer to advertise or tell his customers that he is using this equipment that gives him the highest type of product, and in almost every case we failed in our attempt. We have even offered in the past year to go along and help that out, but I don't think many of them have taken advantage of the sales points for which they spent good money in investment. They have dropped it and advertised some other point in their product as far as sales talks go.

Now if they have purchased this equipment, with a greater premium for both the initial cost and operating cost, they can add something definite to their sales talk. You have noticed in the past ten years how your advertisements on steel have changed from the open hearth advertisement so that practically 70 per cent of the advertisements that appear now are on electric steel cast.

I would like to get an opinion from some manufacturer as to why they are not taking advantage of that chance to put over in their sales talk an advantage that they have bought.

J. O. Keller: Will some of the manufacturers here answer Mr. Russell's question?

R. W. Heller: I don't know of any case in this district, Mr. Chairman, where the manufacturer is advertising his electrically annealed product. It is true, as was pointed out before, that some of them are taking advantage of the electric melting furnace in their advertising, but as far as annealing is concerned, I don't know of such a case.

While time does not permit us to go into a subject as large as bright annealing, I believe Mr. Kniveton's company has done some work in this field. I would like very much to know whether it is being used to any great extent in the East. There are cases in this territory where it is possible to use to advantage electric bright annealing if it can be accomplished in large charges. It would be interesting to have some estimates as to the economies effected in bright annealing furnaces, if the speaker has some available.

James Kniveton: We have worked out a number of problems on the electric bright annealing of steel strip and sheets but I do not have any of the cost figures with me.

I recall one particular case on which I made the initial test. We had a cylindrical dome type furnace in which the strip was practically a solid mass within the chamber, through which we introduced gas. Over the charge was a gas tight dome and between this and the refractory wall of the furnace the heaters were installed. Before the test was started a hole was drilled through the charge as that a couple could be located at the center from top to bottom and also through the total thickness of the charge. A record of the readings were taken at this point as well as the control temperature and also the readings of a third couple at the outside of the charge. During a seventeen-hour operation it was not possible to bring the couple in the center of the charge up to within 300 degrees of the control temperature.

It indicated that a long anneal at a lower temperature was satisfactory to give uniform Erickson and Rockwell readings and to obtain a bright surface.

R. W. Heller: Have you used sheets or strips piled on top of one another in one charge?

One difficulty as I see it, in the bright annealing of steel is to keep from discoloration along the edge, and for some peculiar reason, even with the use of a hood, I believe there is occasionaly a straw color which can be found as far in as half or three-quarters of an inch from the edge. I haven't heard an explanation as to why it occurs or the way to overcome it.

James Kniveton: I think that is a case of making sure of your steel and the fact that you require gas in the chamber during the entire heating and cooling cycle. Some metallurgists disconnect the gas around 700° or possibly 800° or at a point where the charge is below red heat. Others will not disconnect gas until they reach room temperature and they are the ones who are getting the brighter surfaces, from what I have been able to find out.

Wirt Scott: Referring to Mr. Heller's remark about the use of tap chamber transformers, there is, I believe, one application that justifies the use of tap chamber transformers, and that is where a furnace is used for both hardening and tempering. Those furnaces usually are of smaller sizes, for use say in the tool heat treating departments of steel mills, where they want to do hardening and tempering in the same furnace. The furnace is used more for routine work than for production work. For example, hardening the material might require a furnace, say of 100 kilowatt capacity, and that would maintain a temperature, say of 1500° within we will say four or five degrees, plus or minus, but that same furnace is used also for tempering, say a temperature of 500°. You have a capacity of 100 kilowatts that you are trying to control where only about 25 per cent of the amount of power may be required. That means that with this surplus capacity, the inertia which we were talking about this morning, of 100 kilowatt capacity will cause the temperature to over shoot.

You require just as close temperature control at 500° for tempering as you do for the hardening operation. Tools may be spoiled by improper tempering operations just as they may be spoiled by improper hardening; so by using tap chamber transformers and cutting down the power to that required, you can then hold the temperature just as closely for tempering as you can for hardening. Otherwise you may get an overshooting of perhaps 50° due to too much capacity in proportion to the requirements.

A. D. Dauch: Our experience would indicate that tap transformers are used on electric heating furnaces to provide means for using a given resistor. As a general rule, tap transformers are not used to improve furnace operating conditions. In the case Mr. Scott just cited, by introducing a Y series, or a Y delta switch, the rating of the furnace could be automatically cut to one-third in which case it is possible to take care of drawing requirements. This is a common practice on heat treating furnaces of the sizes mentioned. The tap transformer is usually employed for the reason that the resistor cross-section is so large that commercial voltages cannot be applied directly to the resistor. The question of operation of the equipment does not enter into the picture ordinarily.

Wirt Scott: I am not speaking of the larger furnace. I am speaking more or less of the smaller type furnaces, in which it may be very difficult to arrange a star-delta connection. A standard furnace, if you please, not specially designed.

A. D. Dauch: I understood you to say furnaces rated at 100 kilowatts.

Wirt Scott: Well just 100 kilowatts.

A. D. Dauch: You can use Y series switches on furnaces rated as low as 50 kilowatts.

Wirt Scott: Sure, depending on the type of furnace. It may be any type of furnace, but what I have in mind is reducing the voltage where you get tap chamber transformation.

A. D. Dauch: I just wanted to bring out the reason for the use of tap transformers.

Wirt Scott: We have sold a 15 kilowatt furnaces for metallurgical work, for example, where they wanted to use a furnace to make tests through a

very wide temperature range. We supplied them an equipment that gave them something like 25 steps to control, so that regardless of the temperature at which they were operating, they could control it within one or two degrees, plus or minus. That condition was impossible except by means of voltage control.

My remarks relative to tap changing transformers apply only to small standard furnaces that cannot be designed very readily so as to permit the heating elements being regrouped so as to give a reduced capacity. In testing laboratories, great exactness of control may be desired through a wide range of temperatures.

Electric Salt Bath Furnaces for Heat Treating

By A. E. BELLIS*

The subject of this paper is a narrow one, but a thorough consideration of it involves the sciences of Physics, Chemistry and Metallurgy. Applied science is the field of the Engineer and there is nothing more fascinating than applying rapidly growing scientific knowledge to Industrial and other human activities. In applying science to Industrial problems there are two methods.

The classical illustration of the two methods is the development of the well-known miners' safety lamp which was invented practically simultaneously by Davy and Stephenson. Davy, the scientist, figured out the principle that wire gauze being a good heat conductor with large effective area would conduct the heat away from the flame so that the inflammable mine gas could not ignite through the gauze.

Stephenson, the famous engineer, constructed a lamp first using tubes instead of gauze to supply the air for combustion and after he had made a successful lamp figured out the principle underlying his invention.

We all admire Edison's accomplishments and recognize his methods as having perception beyond the trite logic of the most profoundly informed scientist. This something beyond the explicit scientific fact is well illustrated by the recently disclosed story of how the Allies overcame the danger of the Zeppelin.

In 1915 bombs had begun to fall frequently in London from the German Zeppelins. One 700# charge of nitro-glycerine damaged over four hundred buildings. An Inventions Board was organized to listen to every plan for eleminating the danger. Three hundred scientists with every facility set to work on the problem without result. One day a modest individual quietly told an assistant who had had to listen to thousands of fruitless schemes that he had a very simple plan for burning the Zeppelins. "All that was necessary was to put a pinch of dynamite on the nose of a machine gun bullet and when it hit the Zeppelin the gas of the Zeppelin would explode." He was told that it wouldn't work against the soft silk of a Zeppelin bag. He had only tried it out against a brick wall.

Here is where the **applied** scientist stepped in. He went home and tried it against a silk handkerchief stretched on strings and it worked—and the Zeppelin was licked. Of course afterward the scientist studied it and decided that the velocity of the bullet carried a spray of pure nitro-glycerine out in front of it in its flight and the heavy infusorial earth of the dynamite was set back.

The heat treater works in the field of applied science with opportunities for many thrilling discoveries. Science is digging up new facts every day and these are continually finding useful applications. An example of the scientist's point of view and how adaptable his facts are to practical use is shown by Julian Huxley's recent treatise on "Size of Living Things"—an apparently abstract subject.

The smallest living thing—a filter passing bacillus times 10^{24} = the largest living thing—the largest trees. The largest tree magnified the same number of times multiplied the same number oftimes (10^{24}) would be as large as the sun. The sun multiplied the same way would have the size of the finite universe of Einstein. This from the extremely small to the extremely large is $10^{24}+^{24}+^{24}$ or 10^{72} or ten with seventy-two ciphers after it.

But even in this scientific dissertation we find applied science:

"One reason that children require proportionately more food than grown-ups is that their heat loss is relatively greater. A baby a year old loses more than twice as much heat for its weight than does a 170-pound man!"

The logical way to present this subject would be to discuss first (1) the electrical, then (2) the chemical (salt bath) and finally (3) the metallurgical (heat treating) problem. However, because of the way this development has occurred we will take the sequence: (2) Chemical, (3) Metallurgical, and (1) Electrical.

It is pretty well recognized today that a bath is the best means of attaining uniform heat and this outstanding requirement of the heat treater has been in mind in the development of salt baths and salt bath furnaces. It is recognized that if there are no defects such as excessive cost or destructive action on the pot or on the metal treated that a bath has outstanding advantages in quality and quantity of production over all other methods. Even today a great many heat treaters do not realize that there

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are highly developed salt baths available which when used with proper equipment give ideal heating characteristics.

In November, 1922, Tour, in A. S. S. T. Transactions gave the following outline of what he calls a proper salt bath:

"Some eutectic mixture of two or more of the above salts will no doubt be the best solution of the problem.

A proper salt bath for the heat treating of complicated parts of high grade steel other than high speed steel should meet the following requirements:

1. It should have no corrosive or pitting action upon the steel.
2. It should have neither a carburizing nor decarburizing action on the steel.
3. It should melt at some temperature below 1020° Fahr.
4. It should not give off objectionable fumes at 1700°F.
5. It should not attack the cast iron or alloy pot used for heating.
6. It should not deposit a sludge in the bottom of the pot.
7. It should leave only a thin film of molten salt adhering to the piece of steel as the piece is lowered into the quenching bath.
8. The salt and oil mixtures on the steel after quenching should be easily removable by rubbing with waste.
9. The salts should be such that no harm would be done if the steel is tempered while some of the salts still remain upon it.
10. The salts should be non-hygroscopic and have no rust promoting action.

The reason for most of the above requirements is quite obvious. The ideal salt bath would be one which gave no pitting action, which gave the maximum life of pot, and which would not require careful washing of the piece of steel after quenching." Such an ideal salt had not yet been found so far as he was aware.

A patented bath in commercial use in 1921 had for a claim: "A mineral salt bath composition for the heat treatment of metals consisting of an eutectic mixture of potassium chloride and sodium carbonate essentially non-hygroscopic and capable of being heated to 2000°F. without appreciable vaporization."

Another patented bath in commercial use since October, 1918, has the following characteristics:

"My present invention, therefore, has for its primary object to provide such an eutectic fused salt bath which, in addition to its low melting point, will have a relatively high volatilization point and thus afford a relatively wide range of temperatures, in which the mixture of the components will have its greatest fluidity, and in which the components of such mixture will, at all times, remain in the original eutectice proportions in both solid and liquid phases. Owing to the fact that such maximum fluidity is obtained in the eutectic mixture, there is a rapid and uniform circulation of heat throughout all parts of the bath, so that the metal object being treated will be uniformly heated throughout its structure. Also, the low viscosity of the bath minimizes the thickness of the bath film which adheres to the object when it is withdrawn, so that there will be a relatively small loss of the bath material."

Other salt bath materials that have been in wide commercial use since 1925 have the following characteristics, as disclosed by patent specifications: . . . "may be successfully used in the heat treatment of high speed tool steels or alloys, will not deleteriously or harmfuly effect the metal, as by pitting the metal surface or decarburization of the metal. Such harmful effects are usually caused by the presence of undissolved metallic oxides in the bath solution. These oxides also very seriously affect the uniformity in the rate of heating of the metal piece as well as reacting chemically therewith to cause decarburization. The new bath has an automatically acting solvent for such oxides, a clear homogeneous solution is maintained at all times, and the viscosity of the solution remains constant so that the rate of heat transfer through the solution to the metal immersed therein is constant. This rate of heat transfer may, however, be easily controlled and regulated by either increasing or decreasing the components of the bath which changes its viscosity, and thus enables the metal to be treated through a desired temperature range. From the above, it will be apparent that the new bath solution provides a metal heat treating medium whereby uniformly successful results may be attained in the heat treatment of high speed tool steels or alloys owing to the entire absence of undissolved metallic oxides in the bath. Therefore, the bath is maintained in a stable condition and its tendency to decompose or undergo change in composition due to chemical reaction with such oxides is eliminated. Also the protective action of the bath film adhering to the surfaces of the metal when it is withdrawn from the solution is greatly improved." Another patent discloses: "In the heat treatment of metals by immersion in a salt bath of either the eutectic single phase or the non-eutectic multi-phase type, I have succeeded in developing a bath composition which, even after excessive heating at high temperatures, is maintained entirely free of contamination by impurities such as metallic oxides. I have succeeded in accomplishing this result by using as one of the ingredients of the bath a soluble compound which subserves the purpose of a scavenger and immediately dissolves such metallic oxides or other impurities which may enter the bath. In practice, a mixture having a melting point of approximately 1330°F. is very advantageous in the treatment of high grade tool steels at hardening temperatures from 1400° to 1450°F. This bath possesses the property of dissolving metallic oxides so that if such oxides are carried into the bath by the metal being treated, as is usually the case, of if scale forms on the sides of the pot or crucible, these oxides are dissolved in the bath and do not decarburize the metal being treated. Such oxide particles having a high melting point cannot, therefore, cling to the surfaces of the metal and affect the uniformity of its heating or the rate of heating or react chemically with the metal, as by decarburizing steel. In other words, the bath is at all times maintained as a clear homogeneous solution without the accumulation therein of small solid particles of metallic oxides. It has been found that in order to obtain uniformly successful results in the heat treat-

ment of metals in such a salt bath solution, the absence of metallic oxides is of great importance. Thus, first the efficiency of the bath as a heating medium is greatly increased; secondly, the tendency of the bath to decompose or undergo changes in composition due to chemical reaction with such oxides is eliminated; thirdly, the viscosity of the bath may be controlled by regulation of its melting point temperature through increasing or decreasing the proportion of the borates in the bath, thus enabling the metal to be treated through a desired temperature range; and fourthly, the protective action of the bath film adhering to the surfaces of the metal when it is withdrawn from the solution is greatly improved."

From these quotations of specifications and claims on which commercially successfully salt baths have been made, it will be seen that the ideal salt bath material that was being sought ten years ago has been found. That baths with one thousand degree temperature ranges are available is most remarkable when it is considered that water only has a range of existence of 180°F—from 32° to 212°.

Turning from these considerations of the chemical problems to the metallurgical or heat treating results, one must consider that the success of any heat treating job depends on the uniformity of the heating of the pieces to the proper temperature. If one piece is heated hotter than another, or one part of a piece is heated hotter than another part, trouble starts. Sometimes the steel is declared at; sometimes the furnace is condemned. Always the operator is criticized.

The possibilities of overcoming such troubles by using a liquid heating medium has led to the development of a perfected salt bath along the chemical lines mentioned above.

The next most important consideration to the uniformity of heating is the preservation of the surface of the work treated. More trouble and expense is generally involved in preserving or correcting the surface after heat treating than that involved in the actual heat treating operations. Processes of pickling, blasting, washing, grinding, and straightening to "correct" the surface after hardening, or more or less ineffectual methods of packing, preheating, generating reducing atmospheres, etc., to prevent excessive surface changes, are necessary whether the heat treating job is a large scale production of machine parts or a small fine job of high grade tools.

A perfected salt bath will entirely protect the surface from scaling or chemical change, as by carbonizing or decarbonizing. At the same time, the objectionable features of lead and various salts, such as volatilization, poisonous fumes and deterioration of the bath material have been eliminated.

A third important factor in any heat treating job is the rate of heating of the work. Every steel treater knows the disastrous results from too rapid initial heating. The excessive warpage of fine tools, or "unaccountable" brittleness of wire, screw drivers, wrenches, etc., are often due to too rapid heating during the first few seconds in the furnace.

The proper Lavite bath will entirely eliminate this initial heating shock. This is accomplished entirely automatically by the solid film that forms on the work when it is first immersed in the bath. While this film is melting, the work heats relatively slowly; as the film gets thinner the rate of heating increases, and when the film is entirely molten the work heats faster than in any other medium. These conditions give an ideal heating curve from a metallurgical standpoint, just the reverse of conditions in an oven or lead pot furnace.

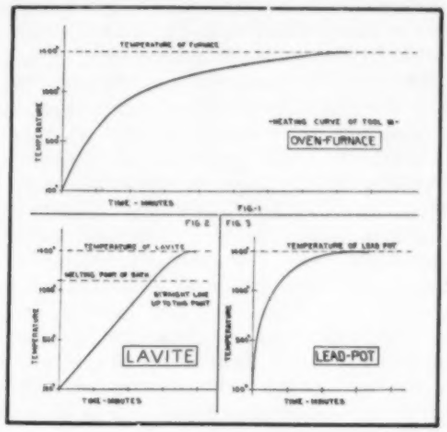


FIG. 1.

The results from these combined advantages of (1) uniform heating, (2) perfectly preserved surface, and (3) controlled rate of heating, is an ideal heating medium from a metallurgical standpoint and one that can be adopted by any shop with small outlay and immediate benefit to the quality of work.

On adopting the principles of liquid heating media to the heat treatment of high speed steel, some radical results and modifications of the generally accepted practice of hardening high speed steel have been developed. It has been the rule-of-thumb instructions for hardening high speed steel for best performance to heat the steel as fast as possible for the last few hundred degrees and to a temperature and time necessary to "sweat" the steel. The quenching or cooling practice has varied from air cooling to quenching in cold oil. Both the "sweating" and the quenching involved necessarily more or less injury to the surface of the steel.

By adapting a Lavite heating bath and a Lavite cooling bath, both of which can be controlled to give the best rates of heating and cooling, it is possible not only to avoid any injury to the surface, but to develop remarkable performance properties in high speed steel, and to eliminate the distortion troubles that have heretofore limited its application to fine tools.

That a better performing tool can be produced from hardening in Lavite is not at all evident on first thought. Indeed, the average heat treater presumes that a tool that "looks at though it hadn't been hardened at all" will not perform so well. The reason for the great possibilities in increasing performance lies in the fact that exactly reproducible conditions can be obtained. A bath of definite volume at a certain temperature will "pump the heat into" a piece of steel of definite size always at the same rate all over the surface of the piece. If a slight modification of hardening temperature or rate of heating will improve the tool, this can readily be determined and a best heat treatment developed.

In annealing wire the importance of the benefits and practice evolved is obvious. Uniform heating and a good surface are the essential factors for obtaining wire that will draw well. The general plan for operating is to suspend coils on yokes. An electric hoist on a jib crane delivers the work to the bath, on the yokes, maintained at 1275 to 1300°F. in the furnace. It is left there for fifteen minutes. The furnace temperature drops 10 to 20° when the load is added, but recovers during the next ten minutes. The wire is removed and allowed to drain on a rack for fifteen minutes while the next load is being heated. After draining, the wire, which has cooled below 500°F., is quenched or washed in water which becomes a solution of the bath material. It has been found that this cooling period is relatively unimportant and frequently a direct quench gives a satisfactory anneal. It is the established practice with some grades of material. This fact has been the source of much controversy and points to the conclusion that the essential factor in most annealing operations is the annealing temperature rather than the rate of cooling. After the heating the wire is uniformly the dull red color characteristic of the temperature. Due to the short duration of the heating cycle, there is no excessive grain growth. No

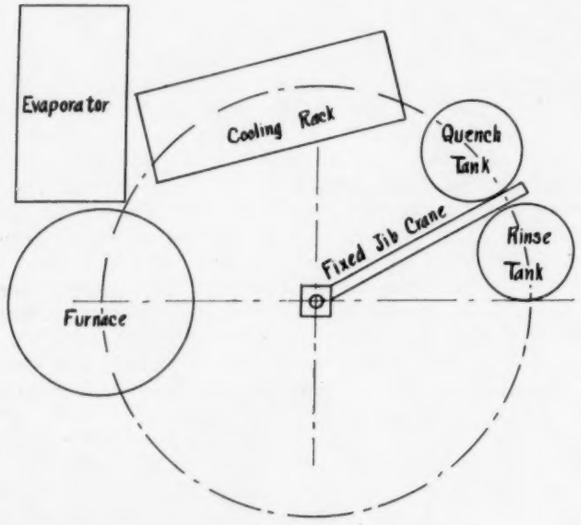


FIG. 2.

single strand gets overheated as there is no temperature gradient necessary for quick heating, as is the case in any oven method. An observation of the coils as they are removed from the bath is much more convincing on these points than any description can be. After the quenching or washing, the coils are rinsed in clean water to remove the solution and then are ready for the lime coating or liquor according to the further processing.

The details of the arrangement of the units to efficiently operate one, two or four units is shown in the sketches. In the single unit plan one man can operate the furnace and handle the loading and washing. With the two furnace unit, two men can handle these operations and in the four furnace unit, three men are needed.

Wire drawn down to 20 gauge is now annealed by this method, special yokes being required for the finer sizes. Strip up to 2 inches wide is now handled on a production basis on the same plan as the round wire is handled, but wider strip has to be handled in a different manner. An interesting practical advantage of the process on the chrome-containing alloys is that pickling of the hot rods is much more easily accomplished after they have been through this anneal, as the method acts to wash off the scale instead of adding to it. In some cases the pickling can be eliminated altogether.

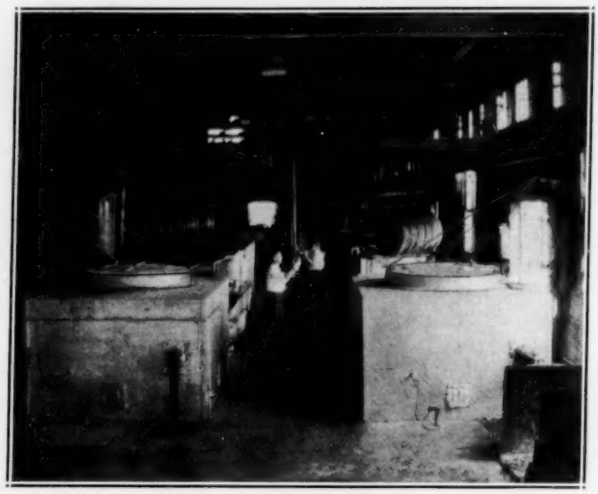


FIG. 3.

An important factor in the economy of the process as applied to production annealing is the recovery of the bath material from the quenching solution. This is carried out by evaporation with the exhaust heat from the furnace vents and is practically automatic. The operator allows enough solution to evaporate each day to make up for the quantity mechanically carried off from the "wetting" of the coils. It is this thin protective "watery" coating that prevents any scaling of the wire in the cooling cycle so that the surface of the wire is unchanged from the annealing process, to the great advantage of the further working or drawing operations. This feature of recovery evaporating has worked out so as to give an easily operated and controlled relationship between the cycles of wire annealing and recovery requiring practically no extra labor and using only heat that would otherwise go to the stack.

The other details of the furnace have been worked out to give a proper heat balance between the work going into the furnace and the volume of the baths. A uniform combustion chamber temperature is essential for satisfactory pot life and is obtained by using pyrometric temperature control. A steel pot lasts six or eight weeks continuous operating and is discarded before failure.

The problem of renewing pots in fuel-fired furnaces; the necessity of getting high temperatures for high speed steel hardening; and the desire to use long rectangular pots for tube and continuous heat treating led to the development of this electric salt bath furnace.

In this new furnace, heat is generated by passing an electric current through the bath itself. This is accomplished by immersing an electrode in the bath and passing current from it to the pot wall.

The resistance of the bath liquid to the current is the only source of heat. There are no metallic resistors in or around the bath. Such resistors have to be heated above their surroundings and cause difficulties from ununiform heating and replacements for deterioration of the metal. These difficulties are eliminated in this furnace where the heat bath itself generates all the heat.

This method of heating at once eliminates the necessity for the pot and its surroundings being hotter than the bath. The heat is generated right in the bath, where it is desired, and the temperature gradient is down hill all the way from the bath out through the pot and support. Also, the pot can be mounted in a heat insulating support with no limit to its thickness, which means great economy in power consumption, and protects the pot on the outside from the atmosphere, so that, coupled with the lower pot temperature for a given bath temperature, the life of the pot is prolonged almost indefinitely. This method achieves almost ultimate simplicity, for there is no apparatus at all around the pot—no burners, no chambers, no coils, no water cooling with its supply and waste piping, nothing but the bare pot set in a heat insulating support, with an electrode dipping into the bath.

Since the heat is not forced to flow through the pot wall into the bath, there is no limit to the amount of heat which can be supplied. Power can be put in at a rate to permit production as fast as the pieces can absorb heat from the bath, without any overheating of the furnace structure.

The power must be supplied at a low voltage, the value depending on the size and type of the pot. For these pots the voltage is eleven volts. This necessitates a transformer which becomes part of the furnace installation, the automatic control being placed on the primary side of the transformer. The transformers with the furnace illustrated are rated at 220 to 11 volts, 20 KVA. At full power input the current to the pot is 1820 amperes, and the supply current is 91 amperes.

A complete analysis of the resistance characteristics of the bath is out of place here, but some essential features follow. The composition of the former High Speed Lavite has been changed by the addition of substances to increase its conductivity when molten, for the original salt had too high a resistance for this method. The salt is an insulator when solid, hence must be melted initially by some other means. Several arrangements for doing this have been developed, one of which is an arc method. When melted, the resistance and hence the power drawn is but little affected by the depth of immersion of the electrode. Hence the electrode is made adjustable, so that the power drawn may be set at any desired value up to the rating of the supply transformer. The electrode itself was subject to oxidation above the bath due to the heat from the bath added to the heat caused by the heavy current it is carrying. Because of this a special alloy for this service has been developed whose electrical and oxidation resisting characteristics are such that it lasts almost indefinitely. The transformer must be located close to the furnace ,since it is not practicable to carry the heavy furnace current any considerable distance, but the transformer is enclosed in a heavy case, needs no attention,and takes up less space than the pot and its support. The power factor is practically unity, a 14-inch pot furnace drawing about 20 KVA when using 20 kilowatts. The heat efficiency is very high, over 90% of the input power being developed as heat in the bath itself. The fact that thick walls and a cover may be used keeps the heat loss down to a low value. In this furnace ten kilowatts is sufficient to hold the temperature with a normal amount of cover removal, leaving ten kilowatts available to heat the work when operating at 2300°F. At lower temperature the heat loss from radiation is relatively less and the rate of heat input can be made very rapid and closely controlled.

These latter advantages are particularly important where intensive continuous production is involved as in wire or tube annealing. This type of furnace has been installed in units up to twenty-five feets long and having output of annealed steel up to six thousand pounds per hour. The possible size of the pot is unlimited and the limit of capacity of heat input is only that of the heat conductivity of the metal involved.

These considerations indicate the two basic benefits from this method of heating—the possibility of getting high temperatures with speed and control; and, the possibility of very rapid quantity production without over-heating the metal being treated. Inherent in the process is low cost because of the very direct application of the heat to the work.

Electric Salt Bath Furnaces for Heat Treating

By A. E. BELLIS

Discussion

F. Rose: I know you gentlemen were all interested in that talk. Since 60 per cent of the Vanadium Alloy Steel products is high-speed steel, I can very well appreciate what grief often comes through improper heat treatment.

Are there any questions that you would like to ask Major Bellis?

R. W. Heller: I would like to know what position the electrode takes in the bath itself, that is, whether it is centrally spaced or off to one side?

A. E. Bellis: That doesn't seem to make a great deal of difference, Mr. Heller. Professor Hall, of Yale University, who did the engineering, made a rule for me that it ought to be the diameter of the

electrode away from the pot. Very often, to speed up the heating the pot, I have set it a little nearer. You can increase the amperage 25 per cent by varying that after you get within the diameter of the electrode from the side of the pot. The pot I showed you on the screen had, I think, an inch and a quarter electrode. Ordinarily that should be more than an inch and a quarter away from the pot. It will affect the amount of current if set any nearer and that will be indicated on the ammeter. I think after you get that far away from the pot, if you go to the center of the pot you don't see any change in it.

R. W. Heller: It would appear to me, Mr. Chairman, that this would be one of the causes of possible rapid pot failure. The fact that the electrode is quite closely located to one particular spot, would tend to cause ununiform deterioration of the whole pot, and it might also affect the heating on the diametrically opposite side.

A. E. Bellis: That is a very good point, and one of our customers brought it up and asked us to make a furnace with two electrodes in the pot. We were very much interested, and we hoped to show that we would use less pots on that furnace. Up to date we haven't shown any benefit. There is one little objection to two electrodes in the pot, and that is you have a little less working room.

H. W. Dexter, Jr.: There are two points which Major Bellis brought out on which I should like to ask questions. The first of these may seem absurb, but please consider that I am an electrical and not a chemical engineer.

In the first place, Major Bellis said that the salt solution used in the bath should be non-hydroscopic. What effect does this characteristic of the solution have since the solution is at the temperatures referred to in his talk?

A. E. Bellis: The advantage of having non-hydroscopic salt, which was mentioned particularly in Tour's paper, was especially noted in wire mills where rusting is quite a problem. It is not the effect in the heated bath; it is the effect of the salt on the wire after the material has been treated. Any remaining on the wire or accidently remaining around the plant, will have quite a bad effect. There was a great prejudice against any kind of salt in a wire mill ten years ago, because one of the large wire companies had been to very great expense, and got into a great deal of trouble by using some kind of a salt in connection with a drawing operation, and as soon as you said "salt" to a wire man he "knew that you couldn't use it."

I think these questions that people apologize for are often the most interesting. We get so in the habit of talking in formulas that sometimes we are not understood. I like very much to answer such questions. I think there is apt to be in some meetings a little frameup; for one manufacturer to ask another manufacturer questions for commercial reasons. If there is any way we can encourage the man who has come here to learn, to ask questions, I wish we could do it, Mr. Rose.

H. W. Dexter, Jr.: Another point which was brought out in the talk is of interest from a power company's standpoint. As I understood from what Major Bellis said, the control of the temperature of the bath is obtained by alternately turning the current on and off to heat the bath. This is accomplished by means of the master switch (or contactor) controlled by the pyrometer. What, in general, is the frequency and duration of these alternations of current on and current off?

A. E. Bellis: On a very small furnace the single phase unbalance is usually not important, but on the three-unit furnace we sometimes put the three transformers on three separate phases, and it often can be worked out on a large job that you can use three or multiples of three transformers on each of the three phases.

I expected some one to ask me why there were five transformers on that large pot. That is a two-phase installation, and I think the reason why they worked it out with five was because they wanted to balance the heating load. The result, from an engineering standpoint, was an improvement in the power factor, due to the surging power load.

M. R. McConnell: I would like to ask Major Bellis how much makeup in salt he has on the job in proportion to the amount of product yield?

A. E. Bellis: Well, that depends altogether on the temperature and the quality of the work. I think on a small tool hardening job, we figure there is a pound of material used up to every hundred pounds treated. There isn't any attempt made there to recover. On a large annealing job, however, the recovery is essential. On the tube annealing and on the larger wire annealing jobs, with the recovery of the bath material, it amounts to a net loss of about two pounds per ton of material treated; that means that this net loss is just wasted. In handling about 25 or 30 pounds must be recovered for every ton annealed.

Wirt Scott: With the salt Major Bellis has developed, is it possible to use a powdered insulating covering directly on top of the salt? In connection with lead baths it is possible and also highly advisable to use a powdered or granular coke covering directly on top of the molten lead, of from 1" to 2" thick, for the purpose of reducing radiation losses during the operation period of the furnace. Will the salt as developed permit the use of a covering directly in contact with the molten bath for accomplishing the same purpose?

A. E. Bellis: No, there isn't any material that can be used for covering bath. It is a good policy to make the working area as small as possible. You have your pot more or less submerged and the only radiation is from the surface area. The chief idea in designing there is to make the radiating surface as small as possible. That is one reason why the relatively deep bath can often be used to better advantage than the shallow bath.

R. W. Heller: To what depth does the electrode go?

A. E. Bellis: The electrode usually goes within two or three inches of the bottom of the pot. That is the policy in order to get uniform heating. It can be made to go closer than that, and thereby pass relatively more current.

R. W. Heller: That gives the uniformity of temperature that you must have?

A. E. Bellis: Of course, there is relatively more heat lost from the top. We sometimes stagger the electrodes and put in a few that don't go down quite so far. The work goes in and out of the top so the top loses more heat. Usually in any kind of furnace

there is contraction of heat toward the bottom. You can design a furnace so as to pass more current out of the bottom of the electrode than out of the side of the electrode. That is something that can be controlled.

R. W. Heller: In what way are the electrodes immersed in the long annealing furnace which was shown?

A. E. Bellis: They just come through the refractory. They have a right angle bend (illustrated by sketch on blackboard). This is the five-foot cover on a three-foot pot. Is that clear? You have to have a clamp here. In this particular case it is nickel. The right angle is here.

R. W. Heller: Then in the case of the long bath, do you stagger the units from side to side?

A. E. Bellis: No, we make pots up to five-feet sections, and put the electrodes down one side of the pot. The reason for that is the characteristics of the bath itself with its rapid heat convection currents.

R. W. Heller: You do get a stirring action?

A. E. Bellis: There is also a stirring action due to the current, but we found that the stirring due to the heating is sufficiently effective to make a satisfactory design of one electrode on one side. Sometimes in a larger pot you can spread the electrodes in the corners, but almost always we put our electrodes on the long side.

R. W. Heller: What would you estimate to be the temperature differential between the center of that pot and the corners, or the opposite side in the case of a long kettle?

A. E. Bellis: After you get equilibrium, if you let the furnace run with the cover on all night, with the five-foot pot and the electrodes on the side, you wouldn't be able to notice any difference. The electrode doesn't get any hotter than the bath.

R. W. Heller: I was thinking of the bath itself.

A. E. Bellis: It gets such a rapid circulation that you can't notice any difference. That is the reason why the salt bath has been interesting. It is the heat uniformity which is inherent in a fluid liquid. In physical chemistry if one wants to get perfect temperature regulation he works with a tub of water, he has everything in a tub of water and he can regulate his temperature and split degrees into hundredths. Of course, it is conceivable that if he had some mechanical circulation there, he could split degrees when he got up to 2,000 degrees.

A. S. Bemis: I should like to ask what material is used in the construction of those pots.

A. E. Bellis: There again you can't safely generalize. For high-speed temperature, we now use cast-steel, and on some of these long pots, steel is satisfactory of welded boiler plate. We have had some experience with welded stainless steel which is also satisfactory. That is just a matter of the chemistry of the bath material with the alloy.

One interesting thing in connection with high-speed steel is whenever we got any nickel in the steel, or if we tried to use a nickel pot, we always got into trouble with high-speed steel. Nickel seems to be a material that we must look out for, but we can even use nickel electrodes on many installations, because nickel, being a good conductor, it is an ideal material.

Dudley Willock: May I ask what the highest temperature is at which you run these baths commercially?

A. E. Bellis: There are many people in the heat treating game who think high-speed steel has to be heated to 2400°. The only remarkable performance I have seen of high-speed temperature above 2300° was 2350° on one of the cobalt steels. That is, 2350° is the highest commercially successful temperature for high-speed steel. I think I can say that a little more dogmatically than I can say anything about the electric furnace. Before I got into the furnace game, my chief interest was the performance of high-speed steel tools.

Charles H. Kenny: What is the maximum current density practical in the bath?

A. E. Bellis: When you talk current densities you have me stopped. I have some notes here on just what the amperage was, but perhaps you must have the area of the electrode. That electrode was 12" long and about an inch and a quarter in diameter and the current is twenty-one hundred amperes on the secondary.

Charles H. Kenny: That was a round electrode?

A. E. Bellis: A round electrode, an inch and a quarter, and 12" in the bath. My note on the primary is that the voltage was 12 and the primary voltage 220, drawing 115 amperes.

The Engineer and His Relation to National Progress

(Continued From Page III)

are pressed into service in large fields and orchards as distributors of poison.

Even the corn borer, one of the most persistent pests with which the farmer has to contend today, finds a properly mechanized farm a most unhealthy place.

These are but a few of the accomplishments of the mechanical engineer after his belated entry into this very important field. What may be accomplished in the future, after the needs are more clearly understood, and with the farmer's son no longer interested in "Old Dobbin" and the one-horse plough, but things mechanical and the State University is indeed something to appeal to the imagination.

When we stop to think of some of the large earnings of the various utility companies and what they really mean from an engineering standpoint, we realize that they represent economy and efficiency with which the energy in fuel has been transferred to useful work.

At the base of this we must recognize that branch of engineering known as combustion, as one of the

prime factors in making available, at a cheap rate and within the reach of everyone, electrical energy. Electrical energy has always existed, but this power was not available nor was it possible for the electrical engineer to design units to produce it cheaply until the combustion engineer had first supplied the power to produce it. The part the combustion engineer has supplied in effecting and bringing about these cheap power rates should not be overlooked.

This brings me to another point—that we are rapidly developing a new class of engineer. The Industrial Engineer. The term is not, of course, to be confused with that of Efficiency Engineer.

To avoid any misunderstanding, at the outset, let me say that in emphasizing the importance of the Industrial Engineer. I have no intention of slighting any of those able men in other fields of Steam engineering, who from time to time have dealt with industrial problems.

I do not minimize the value of the central station engineer who often has to work in the Industrial field, but who seldom recognizes that the two types of engineering are widely different, nor would I suggest that there are no able Industrial engineers. Very little has been written or spoken about Industrial Steam Engineering as a distinct branch of the profession. Direct and often mistaken criticism has been levelled against the Industrial plants. Much has been said about their inefficiency. Some critics would have a wholesale scrapping of industrial steam plants.

Lamentations are heard all over the country about the coal that is being wasted but there is abundant evidence to show that the real problem of the industrial plant is not generally understood.

The trouble is that efficiency as reflected in the saving of fuel, while the prime importance in central stations is of minor and sometimes of no real importance in the Industrial plant. The important thing is the economical production of whatever product the plant in question has to manufacture.

The real object of Industrials should be to develop engineers who, instead of having only an efficiency or rather the B.T.U. point of view, have as well a production or Dollars and Cents point of view and are capable of visualizing whatever has been done or proposed to be done in the steam or power plant or in the heat or power consuming division and its ultimate effect upon the cost sheet of the company concerned.

Chief Features of Basic Open Hearth Construction

By M. J. CONWAY*

OPEN HEARTH PRACTICE FOR THE OPEN HEARTH EMPLOYEE
LESSON NO. I

The following lecture is one of a series which will appear in the Iron and Steel Engineer and was prepared by Mr. M. J. Conway, Combustion Engineer of the Lukens Steel Company at Coatesville, Pa. These lectures were presented before the employees of the Open Hearth Department of the Lukens Steel Company and were illustrated by a model of an Open Hearth Furnace.

It was felt that the preparation and presentation of a series of lectures of this character would bring the employee into closer touch with the design, operation and maintenance of the furnace. At the close of each lecture, the employees were invited to question the various points touched on and these questions and answers will appear at the end of the series.

The Lukens Steel Company is to be congratulated on this particular program of education to the employee.

When these lessons have been printed in the Iron and Steel Engineer the entire course will be reprinted and bound under one corer and will be available to all interested parties at a slight cost.

An open hearth furnace consists of the furnace proper, containing the covered laboratory, hearth or bath, in which the charge is placed; ports for admitting the gas and air over the charge; regenerative chambers, containing checker brick for storing up heat from the products of combustion and imparting it to the cold gas and air; flues and uptakes, connecting the checker chambers with the furnace proper; slag pockets, which are located at the base of the uptakes; flues leading from the air and gas supply (if producer gas is used) to the checker chambers with connections to the stack or waste heat boiler; valves for regulating the direction of flow of gas, air and waste gases; and the stack itself. The furnace proper is located on the level of the charging floor. The slag pockets, checker chambers, flues and valves are all located in the cellar, on a level of about fifteen feet below the charging floor. The checker chambers are not located under the furnace proper but under the charging floor in front of it and the stack and waste heat boilers are placed a short distance beyond. The base of the stack flue sets on a level with the bottom of the checker chambers, but the effect of the stack proper begins at the charging floor level.

The Furnace itself is a rectangular brick structure, supported on the sides and ends by vertical buckstays in the form of I beams or slabs, bound together at their tops, both longitudinally and crosswise, by stays and tie rods. A 100-ton furnace is approximately eighty feet in length and twenty feet in width, outside dimensions over all.

*Combustion Engr., Lukens Steel Co., Coatesville, Pa.

The buckstays are held in place by channels placed at their tops. These channels extend entirely around the furnace, those along the sides being securely tied with bolts and clamps to those crossing the end of the furnace. The front and rear buckstays are united by tie-rods which are two and one-half inch steel rounds; and the ends of these rods are threaded and extend through the buckstays to receive nuts to hold them in place so that they can be tightened and loosened according to the expansion and contraction of the furnace.

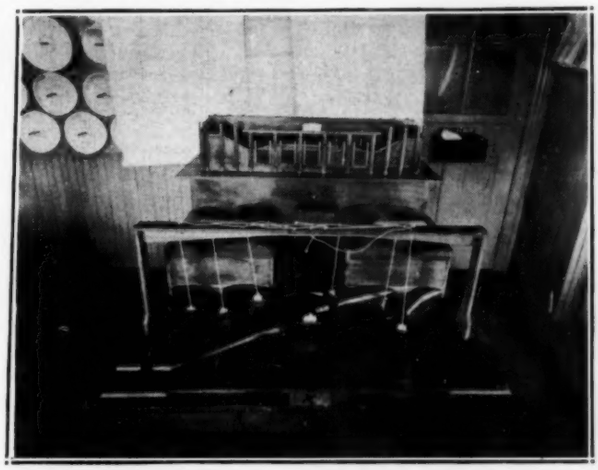


FIG. 1—Assembled model of the Open Hearth Furnace used in the lectures for the employees of the Open Hearth Department of the Lukens Steel Company at Coatesville, Pa.

The foundation of the furnace proper is of such depth and shape as to bear a superimposed load with reasonable safety. The furnace proper comprises the hearth, the side walls and the roof.

The Hearth is constructed as follows: On top of the foundation is placed a layer of three feet or more of second quality firebrick, and upon them is laid a two-foot layer of first quality firebrick in which a number of I beams are placed to act as a bottom anchorage for the vertical buckstays which surround the furnace, a nine-inch layer of magnesite brick is then laid on top of the firebrick, and upon these bricks, a bottom is made up about 12 inches thick with a mixture of burned magnesite, 80%, and ground basic slag, 20%, which is sintered into place.

Dolomite is sometimes substituted for magnesite, but in this case the bottom must be much thicker than when magnesite is used. When completed, the hearth has a form of a shallow dish whose sides extend up to the level of the charging doors.

In order to obtain this shape the succeeding courses of magnesite brick are stepped back, until the normal thickness of the side wall about 13½ inches is reached.

The exact hearth dimensions, inside, between fifteen and sixteen feet in width and thirty-five to forty feet in length, are dependent upon the desired maximum capacity of the furnace and incidental features.

The depth should be such that the bath of molten metal will be from 24 to 30 inches deep. The brick wall of the hearth is pierced at its exact center for the tapping hole, which is about 8 inches in diameter and is provided on the outside with a removable cast iron lip for receiving the end of the steel spout, the function of which is to conduct the molten steel from the furnace to the steel ladle at the time of tapping. In some furnaces a slag hole is placed about fifteen feet from the tap hole and near the upper edge of the hearth, it is surrounded by magnesite brick and is provided with an iron casting at its base for the attachment of the cinder spout.

The Walls are begun on the top course of magnesite brick that surround the upper edge, or brim, of the hearth. They are built of silica brick and to a distance of about eight feet above the charging floor level. The back wall is built up solid except for the tapping hole, but the front walls contain the arched doorways for charging. The doors are usually five in number, the middle one being in the middle of the furnace, and, are so placed that their bases, or sills, are a few inches above the slag line. Each opening is provided usually with a water cooled frame, placed between the buckstays to which it is fastened, and is closed by a water cooled, firebrick lined steel door that may be lifted vertically either by hydraulic or electric power. A wicket, or peep hole, is placed on the center line near the bottom of each door.

The Roof over the hearth is made of silica brick, about twelve inches thick and is arched from front to back. The roof is built independent of the walls, and rests on a skew back brick which in turn is supported by skew back channels that are riveted or bolted to the buckstays of the furnace.

The Bulkheads which form the ends of the hearth below the ports were originally built of solid brick work and were a source of much trouble as they burned out rapidly. These difficulties were all avoided by replacing much of this brickwork with a large, hollow steel chill box with open ends to provide for air cooling.

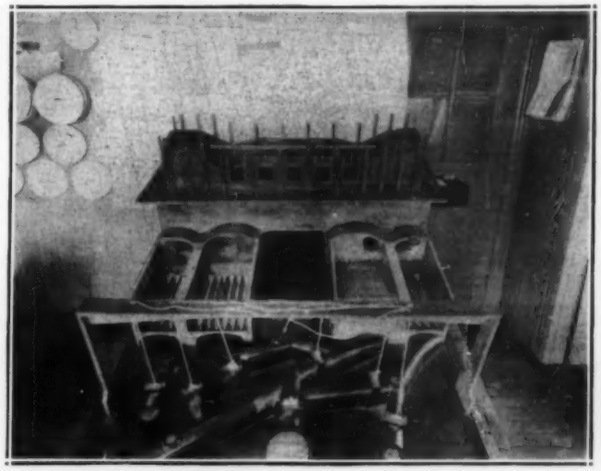


FIG. 2—Model of the Open Hearth Furnace showing piping and gas chambers.

The Air and Gas Ports at each end of the furnace are built at an angle to the back so that the flame is directed against the bath and away from the roof. In order to protect the roof and promote the mixing of the gas and air, the air enters above the

gas. The bricks separating the two ports are in many cases protected by a water cooling system.

Where natural or coke oven gas is used, there is but one port at each end of the furnace, the gas entering on each side of either end of the furnace behind a bridge wall, which extends across the furnace in front of the well, or uptake, from the checkers. This bridge wall is usually made of magnesite brick though chrome brick is well suited for the purpose, and is about thirteen and one-half inches thick and nine inches high.

The Up and Down Takes are the vertical flues which connect the air and gas ports with the slag pockets and the fan-like flues leading to their respective checker chambers. They are built of silica brick and are not water cooled. In producer gas fired furnaces there is a pair of up and down takes for air at each end of the furnace. The up and down takes for the gas rises with their centers coincident with the center line of the furnace and may be built in between the air flues. For most 100-ton furnaces these flues are each four feet by three feet inside dimensions.

Arrangement of Up and Down Takes for Coke Oven Gas, Powdered Coal, Oil and Tar. The construction of the up and down takes in a furnace using natural gas or coke oven gas are simple, as it is necessary to have only one uptake for air at each end of the furnace. In some furnaces this uptake is circular, having a diameter of about six feet, and is therefore called the well. The air as it rises, is deflected downward toward the bath by the port, which extends the full width of the furnace and is arched from back to front, but is straight, longitudinally with a downward slope toward the hearth. This roof is usually about nine inches thick, except near the neck, where it joins the roof of the furnace. Here it increases to twelve inches on account of this point being subjected to the greatest wear. The bridge wall previously described, which crosses the port adjacent to the uptake, causes the incoming air to roll down past the opening from the gas pipe, one of which enters at each side of the port. Thus there are in all four pipes to a furnace. These gas pipes usually have a diameter of three to four inches. A main supply pipe usually serves all of the furnaces in the shop and a branch line, provided with a meter, a valve and a three way cock, leads to each furnace, where it again branches into the pipes entering each side of the ports.

For Tar, Oil and Powdered Coal the same construction as for natural gas has been employed with slight modifications. These fuels are usually employed by inserting the nozzles of the burners through small openings in the brick work closing the ends of the furnace, one burner at each end of the furnace being required.

The Slag Pockets are chambers at the bottom of the uptake and downtake flues. Their functions are to serve as flues to conduct the gases to and from the checkers and to catch any solid matter carried over with the products of combustion, thereby preventing most of this slag material from reaching the checkers and clogging them up. The pockets should be designed large enough so that only in extreme cases do they have to be cleaned out more than once every run. In a 100-ton producer gas fired furnace they are at least four feet wide and eight feet high. The two at each end of the furnace are separated by a thick silica wall. The outside walls are usually 27 inches thick for the air and 31½ inches thick for the gas sides. The former usually has an inside lining of silica brick set against first quality firebrick, while the latter is made of silica brick only. The floor and roof are covered inside with silica brick, the latter being arched on a radius of half the width of the pockets. One end of each pocket merges into a short, fan-like flue, called a neck, which leads to the top of its regenerator chamber.

Regenerators for Producer Gas. The regenerators, of which there are two pairs to a furnace, are built out in front of the furnace and under the charging floor about half below and half above the casting floor level. They are separated from the furnace by a distance of about four feet. Each pair is made up of one checker chamber for gas and one for air, arranged so that the outer wall of the gas chamber is usually in line with the end of the furnace. The

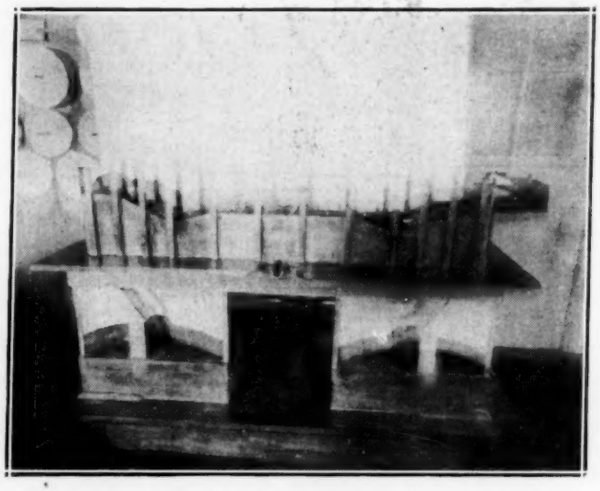


FIG. 3—Rear View of Model Open Hearth Furnaces.

gas chamber is always smaller than the air chamber, because the larger volume of air is necessary to burn the gas and assist in the oxidation of the bath. The total space actually occupied by the checkers in all four chambers is from 120 to 150 cubic feet per ton of furnace capacity. For a 100-ton furnace the volume of the checkers in the air chambers is between 3500 and 4000 cubic feet, while the corresponding volume in the gas chamber is between 2400 and 2700 cubic feet.

The gas chambers on such furnaces, measure inside, about thirty feet long, eight feet wide and sixteen feet high from the bottom to the base of the roof which is arched about 24 inches higher. The air chambers are the same length and height but are about twelve feet wide and the arch in the roof rises about 36 inches. On the floor of the chambers are laid nine inch walls, which divide the chambers longitudinally into three or four flues, respectively, to a height of about four feet. These walls are spanned by firebrick tile, size 3″x12″x31″ and on these tile, the checker work, the best quality firebrick, is begun and continued to within about three to four feet of the top of the chambers. The

arched roofs of the regenerators are constructed of firebrick. The checker work is separated from the flues leading to the slag pockets by a solid wall which rises to their top. This wall aids much in preventing slag and dust from being carried over into the checkers. But in spite of all precautions, some dirt is carried into the checkers which causes them to become choked eventually, when the furnace must be closed down until the checkers are cleaned or replaced.

Regenerators for Oil or Coke Oven Gas. Where these fuels are used, both the gas and air chambers are utilized to preheat the air, which leads to greater efficiency and lower checker chamber temperatures. Where one large checker is operated, the air and stack gases, instead of flowing to all parts of the chamber, tend to take a direct course through the center, thus markedly decreasing the efficiency of the chamber.

Flues and Valves. While the openings into the slag pockets are at the top of the checker work, the openings for the ingress and egress of the gases at the opposite end of the checker chambers are at the bottom. Here the small flue formed by the pier walls open into a large one through valves which lead to the stack flue. These valves, together with mushroom valves in the flues from the air chambers, supply the means by which the reversals of the flame are made. In all modern furnaces these valves are controlled from the charging floor and are so connected that reversal of air and gas flow takes place simultaneously. Since natural gas and coke oven gas cannot be preheated without decomposing them, the valve system in furnaces using these fuels, as well as those using oil, tar and powdered coal, is much simpler than for those using producer gas.

The Stack for each furnace must be of such a size and height as to supply sufficient draught to the furnace. It is lined with first quality firebrick and usually has an inside diameter of 5 feet and a height of from 140 to 160 feet above the charging floor. The shell is made of ¼-inch boiler plate. It usually rests on a concrete foundation, on the same level as the floor of the checker chambers, as previously described. For controlling the draught, a damper is placed in the main flue at its entrance to the stack. With new or clean checkers this damper is partly closed, but as the checkers become clogged, it is raised from time to time as required to maintain sufficient draught on the furnace.

Structural Steel Welding

By FRANK P. McKIBBEN*

Present Status

That the art of welding structural steel by the electric arc is progressing rapidly is shown by the recent successful completion of over seventy-five bridges and buildings which have been wholly or partially welded. Included in these are the following illustrations: (a) A steam power plant 144 ft. in height for Hotel Chalfonte, Atlantic City, fabricated, erected and welded by the Bethlehem Steel Company; (b) a twelve-story addition to Hotel Homestead, Hot Springs, Virginia, fabricated, erected and welded by the American Bridge Company; (c) a half-through plate girder railroad bridge, and a through truss railroad bridge, at plants of the Westinghouse Electric and Manufacturing Company; (d) a large factory building of the mill type and a heavy three-story factory at plants of the General Electric Company; (e) plate girders each carrying 870,000 lbs. central load designed and built by the General Electric Company for use as parts of a thrust bearing in a power plant.

Welding and Building Codes

Many cities are now revising their building codes to permit welding, but even without a specific clause covering welding, many codes permit the process because they include a clause to the effect that if the Commissioner of Buildings is satisfied after proper investigation that a new material or the new use of an old material is safe, he may authorize its use.

The Uniform Building Code prepared by the Pacific Coast Building Officials Conference, containing a section permitting welding, has been adopted by over forty towns and cities, and the American Welding Society's Committee on Building Codes has drafted a code to cover gas and electric welding, which may well serve as a model for cities to follow.

Tests on Welded Joints

Tests on welds may be classified as determining:

1. Longitudinal shearing value of fillets.
2. Transverse shearing value of fillets, involving simultaneous tensile or compressive stresses on some planes within the fillets.
3. Tensile and compressive strengths of welds in butt joints.

Sufficient test data pertaining to strengths of welded joints are available to enable engineers to produce safe designs, but additional tests are desirable to complete a thorough study of this subject.

Tests are needed to throw more light on longitudinal shearing strength of fillets as influenced by length, size and number of layers, and while sufficient work has been done to know that these variables do influence the average strength of the fillets, the exact laws of variation have not been established.

Fillets in transverse shear should give greater strength than in longitudinal shear, because in a properly designed joint the former should have each linear inch of fillet subjected to the same stress; whereas in the latter some inches carry greater

*Consulting Engineer, General Electric Company.

stresses than others just as the end rivets in a row carry greater stresses than does the center rivet.

Welded Plate Girder

Sufficient emphasis has not been laid upon the advantages of welding as compared with riveting in plate girder construction. In a welded girder consisting of a vertical web with one or more plates in each flange, four factors operate to reduce the weight of steel as compared with the weight of riveted girders performing identical functions. These are: Increase in the effective depth, hence greater moment of inertia of cross section for a given weight of steel; general use of gross areas instead of net for tension flanges of welded girders because of the absence of holes; the use of flat bars for web stiffeners instead of angles, thus eliminating the ineffective angle leg against the web; the absence of loose fillers.

The savings in weight resulting from these factors are very considerable; for example, welded and riveted girders of 40 ft. spans carrying 4000 pounds per foot on each entire span and designed for the usual building unit stresses weigh 5467 pounds, 6455 pounds respectively, a saving of 988 pounds, or 15.2 per cent of the riveted girder. With the use of automatic welding machines this large saving in weight should likewise result in a considerable cost reduction.

Qualification of Welders

Before being allowed to weld steel members in an important building, welders should be tested to show their ability to do the kind of work required. These qualification tests should be performed under the supervision of the engineer in charge of the structural steel, who should require the contractor for the steel to show that his welders are qualified to perform the work properly.

These tests should cover; welds in horizontal, vertical and overhead positions; fillets deposited along the offset edges of two plates which upon cooling and breaking apart should show good penetration into the base metals, freedom from gas pockets, slag inclusions and highly colored spots. If the welder's ability is still in question, he should weld some sample butt welds and some longitudinal shear welds which upon testing in tension should show satisfactory tensile and shearing values.

Inspection of Shop and Field Welding

A capable inspector can tell by visual inspection enough about a weld to classify it as good or poor; and inspection has progressed to the point where structural engineers familiar with the subject have ample confidence in welded joints. The inspectors should observe the ammeter to ascertain whether the welder is using the proper current values; should know the chemical composition of the welding wire; should observe by sound and sight whether the arc is short as it should be, or long as it should not be; whether the edges of fillets are sharp and feather-like, or rounded, the former indicating good penetration; whether the fillet and crater are free from gas holes as they should be; whether the crater is of proper depth below surface of the steel.

Tapered Tread Crane Track Wheels

By R. J. HARRY

Electric Overhead Traveling Crane Questionnaire

62 Topics

Opinions and Experiences of the Iron and Steel Industry

DISCUSSION

Developments in E. O. T. Crane Design and Practices

Will Appear in the April Issue of the

Iron and Steel Engineer

This data represents the most complete treatise on E. O. T. Cranes that has ever appeared in print.

Order your extra copies early.

Items of Interest

PERSONNEL CHANGES

Tennessee Coal Iron and Railroad Company announce the following changes:

Karl Landgrebe, formerly General Superintendent of Ensley Works, has been elected Vice President in charge of Blast Furnaces, Steel Works and Rolling Mills, with offices in the Brown Marx Building, Birmingham, Alabama.

C. E. Abbott, formerly Manager of Mines and Quarries, has been elected Vice President in charge of Raw Materials with offices in the Brown Marx Building.

Thomas Chalmers, formerly General Superintendent, Fairfield Sheet Mills and Coke Works, has been elected Vice President in charge of Sheet Mills and Coke Works with offices in Brown Marx Building.

A. B. Haswell, now assistant to the Vice President in Construction, has been appointed to the position of assistant to the Vice Presidents in Engineering and Construction.

R. H. Ledbetter, now Superintendent, Ensley Blast Furnaces, has been appointed to the position of General Superintendent, Ensley Works, with offices at Ensley.

The Pyle-National Company announces the appointment of Clyde V. Root to its sales engineering staff. Mr. Root will be in charge of railroad and industrial floodlighting.

C. A. Bollinger, who has been Master Mechanic of American Sheet and Tin Plate Company, located at Chester, W. Va., has been transferred to their New Castle Works, New Castle, Pa., in the same capacity.

H. P. Tustin, formerly Combustion Engineer, American Sheet and Tin Plate Company at the New Castle Works, succeeds C. A. Bollinger as Master Mechanic at the Chester, W. Va., plant of the American Sheet and Tin Plate Company.

The H. E. Burns Company, Inc., 221 Fourth avenue, Pittsburgh, Pa., have been appointed Pittsburgh district representatives of the Standard Transformer Company of Warren, Ohio. The Burns Company will handle a complete line of transformers.

Combustion Engineering Corporation, New York, announces the removal of their Hazleton, Penna., representative, the Coxe Stoker Engineering Company, to their new quarters, room 1109 to 1114 Markle Bank Building.

L. C. Bullington, formerly Manager of the Detroit Office of the Westinghouse Electric and Manufacturing Company, recently was appointed General Sales Supervisor of that company with his office at the East Pittsburgh Works.

Effective February 1, M. C. Steffen becomes Manager of the Cincinnati office of Cutler-Hammer, Inc., pioneer manufacturers of Electric Control Apparatus, with headquarters at Milwaukee, Wis. Mr. Steffen takes the place of R. I. Maujer, who has resigned.

Mr. Steffen comes to Cincinnati from the St. Louis office of C-H, where he has been stationed the last five years.

Union Electric Manufacturing Company, 926 Juneau avenue, Milwaukee, Wis., has announced the appointment of John R. Patterson as District Manager of their new Chicago offices located at 210 Lomax Building, 1608 West Madison street, Chicago, Illinois.

R. F. Luke has been appointed as an associate with Mr. Patterson in the Chicago office. Mr. Luke started his career with the Union Electric Manufacturing Company as a student engineer.

C. L. Russell, who has been on the sales force of the Union Electric Manufacturing Company for over ten years, has been transferred from the Chicago office to the Milwaukee factory.

Garritt S. Felt was appointed as District Manager, with headquarters at room 404 Merchants National Bank Building, Omaha, Neb.

The Union Electric Manufacturing Company, makers of electrical motor control equipment, both manual and automatic, are carrying out an extensive program of expansion in their sales territories and in the factory.

Jefferson Electric Company announces that L. H. Byrne has been appointed acting Western Sales Manager. Mr. Byrne previously traveled Wisconsin, Minnesota, North Dakota and part of Canada. A. H. Firnhaber will take over Mr. Byrne's territory. E. B. Charlton will cover the northeastern part of New Jersey and the southeastern part of Pennsylvania. R. W. Bowen has been recently appointed to cover Virginia, Maryland and North Carolina, and J. A. Ryan eastern New York. J. B. Sullivan has been retained to help cover the Chicago territory.

Effective February 1, Frank J. Burd becomes Manager of the Philadelphia office for Cutler-Hammer, Inc., pioneer manufacturers of electrical control apparatus, with main office at Milwaukee, Wis. Mr. Burd replaces T. E. Beddoe, who has resigned.

S. B. Taylor has been recently promoted to Assistant Works Manager of the Reliance Electric & Engineering Company, Cleveland, Ohio.

About March 1 the Trumbull Electric Manufacturing Company of San Francisco will move their offices to 432 Fourth street.

This office has combined with that of the A G Electric Manufacturing Company, which plant was purchased by the Trumbull Electric Manufacturing Company some few months ago.

The Trumbull Electric Manufacturing Company has opened a Detroit office at 308 Architects Building, 415 Brainard street.

This office is combined with a former office of the A G Electric Manufacturing Company which at that time was managed by David Laird, who is now one of the Engineers of the Trumbull Company. C. L. Baier, the local Trumbull representative, makes his headquarters at this new Trumbull office. This office is part of the Chicago district.

NEWS OF THE PLANTS

American Rolling Mill Company has taken option on 230 acres of land on the Detroit river as a site for a $20,000,000 steel plant, which will be a complete unit to supply automobile makers.

It was officially stated at Middletown, O., however, that it is very indefinite at present whether the company will exercise its option to erect a plant in that section of the country.

The Electrical Department of the Ashland Plant of the American Rolling Mill Company held their Second Annual Safety Frolic at the Henry Clay Hotel, Ashland, Kentucky, on January 25, 1930. T. J. Flaherty, Electrical Superintendent of the Ashland plant, acted as toastmaster. The speakers of the evening were J. E. Funderburg, foreman of the East End section and winner of the safety contest; C. M. Allen, Supervisor of Safety and Training, Ashland; R. G. Adair, Supervisor of Safety and Training, Middletown; R. R. Smith, Assistant General Superintendent; G. P. Hansen, General Superintendent; F. E. Vigor, Works Manager, Ashland; J. C. Miller, Vice President, Ashland, and S. R. Rectanus, Vice President, Middletown.

Bethlehem Steel Corporation, under its Pension Plan, paid $548,970.88 to 1,214 pensioned employees last year, according to a report just compiled. There were 1,105 retired employees remaining on the pension roll December 31, 1929, receiving an average pension of $504.96 a year. The average age of these employees when pensioned was 65 years, 11 months.

Bethlehem's formal pension plan has been in operation seven years. The total amount of pensions paid during this period was $3,036,948.56.

Bethlehem had 1,105 active pensioners at the end of 1929, 244 of whom had individual service records of over 45 years to their credit. This figure includes 102 having in excess of 50 years service, 26 of whom had more than 55 years of service, two of the latter having records of more than 60 years.

During 1929, 137 new pensioners were added and 109 were terminated.

NEWS FROM THE MANUFACTURERS

The Brown Instrument Company of Philadelphia have prepared a very attractive 32-page booklet on Remote Type Instruments for measuring pressures, liquid levels, flows and for indicating positions. Interested parties may obtain copies by asking for catalog number 7501.

"Engineering Achievements of 1929" is the title of a very interesting booklet being distributed by the Westinghouse Electric & Mfg. Co. of East Pittsburgh, Pa. Copy of the booklet may be had by writing the above company.

The Cutler Hammer Company of Milwaukee, Wisconsin, are distributing a booklet entitled "Practical Pointers on the Selection of Motor Control." Copy of the booklet may be had by writing to above concern.

The Westinghouse Electric and Manufacturing Company has published a new, illustrated, 20-page circular on Type CL Carbon Circuit Breakers.

The booklet includes several installation photographs showing the breakers installed in a coast guard cutter, in a steel mill and in office buildings. Several other photographs show construction details of the breakers. These photographs and the text present a clear description of the CL line, emphasizing the new and improved features of the breakers.

The foreword of the publication contains a brief history of the development of carbon circuit breakers and tells of the rapid strides made recently in designing this equipment.

The booklet may be obtained from any office of the Westinghouse Electric and Manufacturing Company by requesting Circular 1705-B.

Several improvements have been added to the 1930 model of the U. S. Doublenclosed Motor manufactured by the U. S. Electrical Mfg. Co. of Los Angeles. This motor is said to have all the advantages of a fully enclosed motor and also embodies Asbestos protection wherein the wires are insulated by the incombustible fibres of Asbestos in conjunction with a heat-resisting compound known as Asbestosite.

Its service is more general in industries where dangerous fumes, moisture, dripping water, atmosphere heavily laden with abrasive particles and dripping acids and alkalis are prevalent. A bulletin describing the U. S. Doublenclosed Motor may be obtained by writing to the manufacturers.

The Bethlehem Steel Corporation of Bethlehem, Pennsylvania, has recently awarded to Electric Machinery Manufacturing Company, Minneapolis, Minnesota, an order for ten 300 H.P. and four 500 H.P. Synchronous Motors. The motors will be installed in their Cambria plant at Cambria, Pennsylvania, and will operate at 750 r.p.m., on a 25 cycle, 6600 volt circuit.

The 300 H.P. motors are to be coupled to Gas Disintegrators used in washing the blast furnace gases. Each of the four 400 H.P. motors will be directly coupled to centrifugal pumps.

Fred M. Kimball, advisory manager of the motor division of the industrial department of the General Electric Company, died February 5, in Lynn, Massachusetts. Mr. Kimball had seen many years of service with General Electric and was well-known throughout the motor industry. He had been ill for some time.

He was born in Barton, Vermont, July 7, 1861, and received his education in Massachusetts, including a course in electrical engineering at Massachusetts Institute of Technology.

NORMAN C. BYE,
Chairman

F. O. SCHNURE,
Executive Committee

KENNETH M. RAYNOR,
Vice Chairman

PHILADELPHIA DISTRICT SECTION

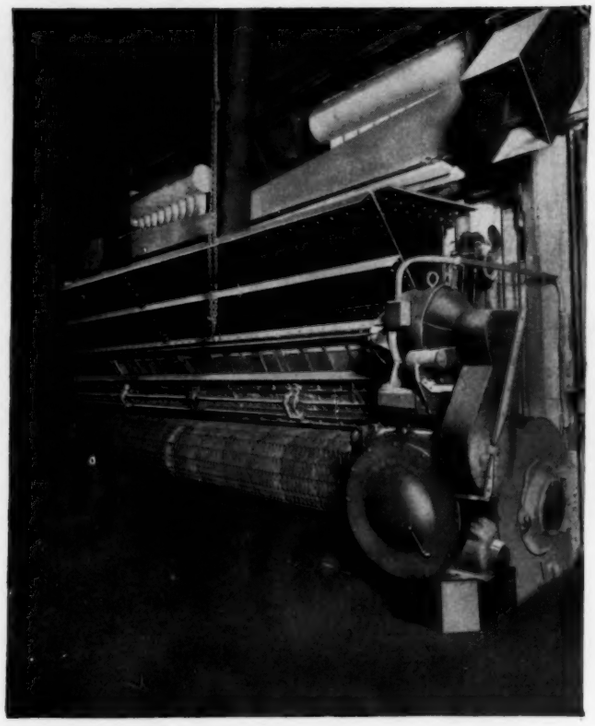
EXECUTIVE OFFICERS
1929 — 1930

MEETINGS
Saturday, April 5, 1930
Friday, May 2, 1930

GEORGE PFEFFER,
Past Chairman

LINN O. MORROW,
Secretary

H. D. ESTERLY,
Executive Committee



Front view of one of the C-E Stokers (Green Forced Draft type) 22 ft. long by 24 ft. wide, 528 sq. ft. effective grate surface.

Grand Avenue adds a . . . . .

5th C-E Unit

These five C-E units are placed in the space previously occupied by twenty small boilers and have a capacity of approximately 625,000 lbs. of steam more than the twenty old units.

The latest Combustion Steam Generating unit comprises:
C-E Stoker—Green forced draft type—
C-E Boiler—Heine V-type, nominal rating 1516 H.P. designed for 700 lb. maximum working pressure. C-E side wall furnace screen—C-E plate type Air Preheater and water-cooled front and rear stoker arches.

This installation is an excellent example of co-ordinated design. The fuel burning and steam generating equipment was sold and installed under one contract—one responsibility and one set of guarantees.

COMBUSTION ENGINEERING CORPORATION
200 Madison Avenue, New York, N.Y.